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ShipMo3D Version 3.0 User Manual for Computing Ship Motions in the Time and Frequency Domains

Kevin McTaggart

Defence R&D Canada – Atlantic

Technical Memorandum
DRDC Atlantic TM 2011-308
January 2012

Canada

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Abstract

ShipMo3D is an object-oriented library with associated user applications for predicting ship motions, with Version 3 introducing modelling of sloshing tanks and U-tube tanks. This report serves as a user manual for ship motion predictions in the time and frequency domains using ShipMo3D Version 3. A companion report serves as a user manual for building ship models that are used as input for ship motion predictions. Time domain simulations can model a freely maneuvering ship in calm water or in waves. SM3DBuildSeaway builds seaway models representing regular or random seaways, including long and short-crested seaways. SM3DFreeMo simulates a freely maneuvering ship in calm water or in a modelled seaway. Several ShipMo3D applications predict ship motions in the frequency domain for a ship with quasi-steady speed and heading. SM3DSeakeepRegular predicts motions in regular waves. The applications SM3DSeakeepRandom, SM3DSeakeepSeaway, and SM3DSeakeepSeawayFromRaos predict motions in random waves. SM3DTimeSeries-FromRaos produces ship motion time series for a ship with quasi-steady speed and heading based on previously predicted motion response amplitude operators.

Résumé

ShipMo3D est une bibliothèque objet avec applications utilisateur connexes pour la prévision des mouvements de navires dans le domaine temporel et le domaine fréquentiel. La version 3 comprend la modélisation de citernes à ballottement et de citernes à tube en U. Le présent rapport sert de manuel de l'utilisateur pour la prévision du mouvement de navires dans le domaine temporel et dans le domaine fréquentiel, à l'aide de la version 3 de ShipMo3D. Un rapport d'accompagnement sert de manuel de l'utilisateur pour la construction de modèles de navires qui sont utilisés pour entrer des données sur la prévision du mouvement. Les simulations du domaine temporel permettent de modéliser un navire en manœuvre libre et en eau calme ou dans les vagues. SM3DBuildSeaway construit des modèles de voie maritime à trajet régulier ou aléatoire, y compris des voies pour le transport maritime à courte ou longue distance. L'application SM3DFreeMo simule un navire manœuvrant librement en eau calme ou dans une voie maritime modélisée. Plusieurs applications du logiciel ShipMo3D font des prévisions des mouvements de navires dans le domaine fréquentiel, pour un navire à vitesse quasi constante dans des vagues régulières et tenant le cap. L'application SM3DSeakeepRegular prévoit des mouvements dans des vagues régulières. Les applications SM3DSeakeepRandom, SM3DseakeepSeaway et SM3DSeakeepSeawayFromRaos font des prévisions du mouvement dans des vagues aléatoires. L'application SM3DTimeSeriesFromRaos produit des séries temporelles du mouvement de navires pour un navire à vitesse quasi constante et tenant le cap, à partir d'opérateur d'amplitude de réponses de mouvements prévues.

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Executive summary

ShipMo3D Version 3.0 User Manual for Computing Ship Motions in the Time and Frequency Domains

Kevin McTaggart; DRDC Atlantic TM 2011-308; Defence Research and Development Canada – Atlantic; January 2012.

Introduction: Ship motions influence the performance and safety of naval personnel and systems. Consequently, ship motion predictions are often used to support ship design and operation. Time domain analysis is required to model motions if a ship is freely maneuvering or in a heavy seaway. Frequency domain predictions are computationally efficient and suitable for ships travelling with steady speed and heading in moderate seaways.

Principal Results: ShipMo3D is an object-oriented library with associated user applications for predicting ship motions in calm water and in waves. Motion predictions are available in both the time domain and the frequency domain. For predictions in the time domain, the ship can be freely maneuvering in either calm water or in waves. This report serves as a user manual for computing ship motions using Version 3. A companion report provides a user manual for creating ship models required as input for computing motions. ShipMo3D Version 3 introduces capabilities for modelling U-tube tanks and sloshing tanks.

Significance of Results: ShipMo3D continues to be suitable for providing predictions of ship motions in waves. These simulations can be used for various applications, including engineering analysis, operations analysis, and training.

Future Plans: ShipMo3D Version 3 will be incorporated into simulations modelling naval platform systems using the High Level Architecture.

Sommaire

ShipMo3D Version 3.0 User Manual for Computing Ship Motions in the Time and Frequency Domains

Kevin McTaggart ; DRDC Atlantic TM 2011-308 ; Recherche et développement pour la défense Canada – Atlantique ; janvier 2012.

Introduction : Les mouvements de navires ont une influence sur le rendement et la sécurité du personnel et des systèmes navals. Par conséquent, les prévisions des mouvements de navires sont souvent utilisées en appui à la conception et à l'exploitation des navires. L'analyse du domaine temporel est requise pour modéliser les mouvements si un navire manœuvre librement ou dans une voie maritime très occupée. Les prévisions du domaine fréquentiel sont efficaces sur le plan des calculs et conviennent aux navires qui naviguent à vitesse continue et font cap dans des voies maritimes moyennement occupées.

Résultats principaux : ShipMo3D est une bibliothèque objet avec applications utilisateur connexes pour la prévision des mouvements de navires en eau calme et dans les vagues. Les prévisions des mouvements sont disponibles dans le domaine temporel et dans le domaine fréquentiel. Pour les prévisions dans le domaine temporel, le navire peut manœuvrer librement dans les eaux calmes ou dans les vagues. Le présent document sert de manuel de l'utilisateur pour calculer les mouvements de navires à l'aide de la version 3. Un rapport d'accompagnement sert de manuel de l'utilisateur pour la construction de modèles de navires qui sont requis pour entrer des données servant à calculer les mouvements. La version du logiciel ShipMo3D introduit des capacités de modélisation des citernes à tube en U et des citernes à ballottement.

Importance des résultats : Le logiciel ShipMo3D convient toujours pour la prévision des mouvements de navires dans les vagues. Les simulations peuvent être utilisées pour différentes applications, y compris l'analyse technique, l'analyse des opérations et la formation.

Travaux ultérieurs prévus : La version 3 du logiciel ShipMo3D sera intégrée à des simulations modélisant des systèmes de plates formes navales à l'aide de l'architecture de haut niveau.

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1 Introduction

ShipMo3D is an object-oriented library with associated applications for predicting ship motions. This report describes applications for predicting ship motions in the time and frequency domains. A companion report [1] is the user manual for creating ship models required for computing ship motions. For each ShipMo3D application, user input is read from an ASCII input file. Each application produces an ASCII output file, and many applications also produce graphical output. The ShipMo3D graphical user interface (GUI), ShipMo3D30.exe, can be used to interactively prepare input data, launch applications, and view output results.

Several reports describe the theory behind ShipMo3D, and also give verification and validation of ShipMo3D results. References 2 and 3 describe the prediction of hull hydrodynamic forces. The modelling of seaways is described in Reference 4. Reference 5 covers appendage and viscous forces, which are important for predicting lateral plane motions. The extension of ShipMo3D to freely maneuvering ships is described in Reference 6, with refinements to maneuvering forces given in Reference 7. ShipMo3D Version 3.0 introduces modelling of U-tube tanks [8] and sloshing in tanks with free surfaces [9]. Reference 10 gives validation results for Version 3.0 of ShipMo3D.

Section 2 of this report describes features that are new for Version 3 of ShipMo3D. Section 3 gives an overview of predicting motions using ShipMo3D. Section 4 describes coordinate systems used for motions and ship geometry. Section 5 describes the application SM3DBuildSeaway for building a model of a seaway. Time domain motions in a seaway or in calm water can be computed using SM3DFreeMo, described in Section 6. Sections 7, 8, 9 and 10 describe the applications SM3DSeakeepRegular, SM3DSeakeepRandom, SM3DSeakeepSeaway, and SM3DSeakeepSeawayFromRaos which are used to predict motions in the frequency domain for various types of sea conditions. The post-processing program SM3DTimeSeriesFromRaos is described in Section 11. Section 12 describes inputs for the rudder autopilot and Section 13 describes various inputs for seakeeping predictions in random seas. Final conclusions are given in Section 14. Annexes at the end of the report give input file descriptions and sample input and output files for the ShipMo3D applications.

Detailed input formats and sampled files are given in Annexes A to G. For brevity, some portions of sample output files have been removed from this document; however, full sample output files are available for the software.

2 New Features for ShipMo3D Version 3

ShipMo3D Version 3 supercedes Version 2 [11, 12]. Version 3 includes several major enhancements, and also has many minor code improvements.

2.1 High Frequency Approximation for Evaluating Retardation Functions

When computing wave radiation damping forces in the time domain, retardation functions are used [3]. The retardation functions are computed from wave radiation damping coefficients evaluated in the frequency domain. ShipMo3D Version 3 uses the following high frequency approximation for damping coefficients when computing retardation functions within SM3DBuildShip:

$$B_{ij}(\omega_e) \;=\; B_{ij}(\omega_e^*) \; \exp\left(-2\omega_e/\omega_e^* \;+\; 2\right) \;\text{for}\; \omega_e \geq \omega_e^* \tag{1}$$

where B_{ij} is frequency domain damping for motion modes i and j, ω_e is wave encounter frequency, and ω_e^* is the highest encounter frequency for damping coefficients used for computing retardation functions. The above approximation helps to eliminate oscillatory behaviour of retardation functions at the maximum frequency ω_e^*.

The following high frequency approximation from Nam et al. [13] was originally considered for implementation in ShipMo3D:

$$B_{ij}(\omega_e) \;=\; B_{ij}(\omega_e^*) \left(\frac{\omega_e^*}{\omega_e}\right)^2 \;\text{for}\; \omega_e \geq \omega_e^* \tag{2}$$

Equation (1) provides faster decay of damping coefficients at higher frequencies, and appears to give better modelling of actual behaviour. Note that Equations (1) and (2) give similar behaviour of the variation of damping coefficients with encounter frequency when encounter frequency ω_e is approximately equal to the maximum frequency ω_e^*.

2.2 Modelling of U-tube Tanks for Roll Stabilization

ShipMo3D can now model U-tube tanks for roll stabilization. Hydrodynamic forces are evaluated using the method of Lloyd [14], with ShipMo3D implementation described in Reference 8. Dimensions for U-tube tanks are given as input to SM3D-BuildShip.

2.3 Modelling of Sloshing in Tanks with Free Surfaces

ShipMo3D can now model sloshing in tanks with free surfaces. Examples of such tanks are cargo tanks and flume tanks for roll stabilization. SM3DPanelSloshTank builds a panelled representation of a sloshing tank. SM3DRadSloshTank computes sloshing hydrodynamic forces in the frequency domain based on the approaches of Malenica et al. [15] and Newman [16], with the ShipMo3D implementation described in Reference 9. Output sloshing tank data from SM3DRadSloshTank can be used as input to SM3DBuildShip when building ship models.

2.4 Application SM3DSeakeepSeawayFromRaos for Predicting Motions in a Seaway Using Input Response Amplitude Operators

The new application SM3DSeakeepSeawayFromRaos can predict motions in the frequency domain for a ship travelling in a seaway defined in earth-fixed axes. SM3DSeakeepSeawayFromRaos reads pre-computed motion response amplitude operators (RAOs) which can be computed by SM3DSeakeepRandom. SM3DSeakeepSeawayFromRaos runs faster than SM3DSeakeepSeaway, and is suitable for applications such as real-time operator guidance.

2.5 Prediction of Motion Sickness Incidence in the Frequency Domain

When predicting ship motions in the frequency domain, the applications SM3DSeakeepRandom, SM3DSeakeepSeaway, and SM3DSeakeepSeawayFromRaos can now predict motion sickness incidence. Colwell [17] describes the approaches used for evaluating motion sickness incidence.

2.6 Output of Motion Response Amplitude Operators for Operability Analysis Using SHIPOP2

The frequency domain application SM3DSeakeepRandom can now write motion response amplitude operators in SHIPMO7 ASCII post-processing format, which can be used as input for operability analysis using SHIPOP2 [18].

3 Overview of Using ShipMo3D for Computing Ship Motions

When computing ship motions in waves, the first step is to build a model of a ship that can be used by ship motion programs. The ShipMo3D manual for building ship models [1] gives details regarding the following applications:

SM3DPanelHull: Develops a model of the hull surface represented using triangular and quadrilateral panels. Also computes hydrostatic properties for the submerged portion of the hull.

SM3DRadDif: Computes hydrodynamic added mass and radiation damping. Also computes forces due to incident and diffracted waves.

SM3DPanelSloshTank: Develops a model of the the surface of a sloshing tank represented using triangular and quadrilateral panels.

SM3DRadSloshTank: Computes sloshing tank hydrodynamic added mass and radiation damping.

SM3DBuildShip: Builds a model of the ship including all components relevant to predicting ship motions.

Once a ship model has been created, it can be used for predicting motions in the time or frequency domains. The following programs are used for predicting motions in the time domain:

SM3DBuildSeaway: Builds a model of a regular or pseudo-random seaway.

SM3DFreeShip: Computes motions of a freely maneuvering ship in calm water or a seaway.

The following applications can be used for frequency domain analysis:

SM3DSeakeepRegular: Computes frequency domain motions of a ship in a regular seaway (waves of constant heading, frequency, and amplitude).

SM3DSeakeepRandom: Computes frequency domain motions of a ship in a random seaway, with sea direction considered relative to ship direction. A random seaway is considered to have a principal direction, and waves must be unidirectional or defined by a spreading function relative to the principal wave direction.

SM3DSeakeepSeaway: Computes frequency domain motions of a ship in a random seaway, with the seaway described in earth-fixed axes and ship heading

given by absolute direction (relative to the ship heading north). A random seaway in earth-fixed axes can be unidirectional or can have arbitrary directional spreading.

SM3DSeakeepSeawayFromRaos: Computes frequency domain motions of a ship in a random seaway using previously computed RAOs, with the seaway described in earth-fixed axes and ship heading given by absolute direction (relative to the ship heading north). Input RAOs are typically computed by SM3DSeakeepRandom.

SM3DTimeSeriesFromRaos: Computes ship motions in the time domain based on response amplitude operators (RAOs) generated by SM3DSeakeepRegular, SM3DSeakeepRandom, or SM3DSeakeepSeaway.

SM3DSeakeepRegular gives motion predictions for a ship in regular sinusoidal waves, and is most likely to be used for validating ship motion predictions with experiments in regular waves. SM3DSeakeepRandom gives motion predictions for a ship in random waves with a principal sea direction. Within SM3DSeakeepRandom, a seaway spectrum is represented by a point wave spectrum and an optional spreading angle applied to a cosine-squared spreading function. Input, output, and computations with SM3DSeakeepRandom consider the principal sea direction relative to the ship heading (180 degrees for head seas, 90 degrees for seas from port). SM3DSeakeepRandom is most likely to be used for general seakeeping and operability analysis. SM3DSeakeepSeaway gives motion predictions for a ship in a seaway described by a wave spectrum with a fixed orientation, such as a multi-directional wave spectrum that has been measured using a wave buoy or wave radar system. Input, output, and computations with SM3DSeakeepSeaway consider ship heading (0 degrees for the ship heading north). SM3DSeakeepSeaway is most likely to be used for comparing predictions with full-scale trials and for real-time operator guidance systems. SM3DSeakeepSeawayFromRaos gives output similar to SM3DSeakeepSeaway, but has faster execution because it uses pre-computed RAOs.

Frequency domain motion predictions are essentially linear; however, the nonlinear influence of roll motion amplitude on roll damping is modelled. ShipMo3D roll damping computations are described in detail in Reference 5. For SM3DSeakeepRegular, roll amplitude and associated roll damping are evaluated iteratively for each combination of ship speed, heading, wave frequency, and wave amplitude. For SM3DSeakeep-Random, RMS roll motion and associated roll damping are evaluated iteratively in long-crested seas for each combination of wave spectrum, ship speed, and heading. The following relationship is used for determining effective roll amplitude and associated roll damping in random seas:

$$|\eta_4| = 1.25\, \sigma(\eta_4) \tag{3}$$

where $|\eta_4|$ is the roll amplitude used for roll damping computations and $\sigma(\eta_4)$ is the RMS roll motion. For SM3DSeakeepSeaway, RMS roll motion and associated roll damping are evaluated iteratively with the specified wave spectrum for each combination of ship speed and absolute ship heading. Unlike SM3DSeakeepRandom, SM3DSeakeepSeaway considers the influence of short-crested waves when determining roll response amplitude operators (RAOs); however, roll RAOs from SM3DSeakeep-Seaway can only be considered valid for the specific combination of earth-fixed wave spectrum, ship speed, and absolute ship heading.

Predicted ship motion RAOs from SM3DSeakeepRegular, SM3DSeakeepRandom, or SM3DSeakeepSeaway can be used for generating time series of ship motions with SM3DTimeSeriesFromRaos. Alternatively, time series of ship motion can be generated directly using SM3DFreeMo.

ShipMo3D applications use 4 main types of files. User input data are read from input files with names ending with ".inp". Application output data for review by the user are written to output files with names ending with ".out". Transfer of data between applications is done mostly using files in .NET binary format, with names ending with ".bin". Transfer of seaway data between applications is done using files in .NET XML format, with names ending with ".xml". The usage of XML format for seaway data facilitates usage of seaway data by external applications, such as visualizers.

Each ShipMo3D application has default file names for input and output. Prefixes can be added to default file names by typing "-p PREFIX" as a command line option, where PREFIX is the specified file name prefix (e.g., the ship name). Alternatively, full input and output file names can be specifed on the command line. Input file names can be specified by typing "-i INFILE" as a command line option, where INFILE is the specified input file name. Similarly, output file names can be specified by typing "-o OUTFILE" as a command line option, where OUTFILE is the specified output file name. The command line option "-h" shows any command line arguments associated with a ShipMo3D application. The command line option "-e" specifies that exceptions that occur during program execution should be fully written to the console. Table 1 summarizes command line options.

Table 1: *Command Line Options for ShipMo3D Applications*

-p PREFIX	Input and output file names have prefix PREFIX
-i INFILE	Input file name is INFILE
-o OUTFILE	Output file name is OUTFILE
-h	Help is written to output console
-e	Execution exceptions are written to console

ShipMo3D user input files are in ASCII format. Each input line typically begins with a tag denoting the contents of the input line. Comments can be inserted into a file using the character "#" to denote a comment line or the beginning of a comment after other input on a line. An exclamation mark "!" denotes that an input line is continued on the next line. Here is some sample input demonstrating the usage of the comment and continuation characters:

```
# Sample input from a SM3DSeakeepRegular input file.
seaDirsDeg 0.0 15.0 30.0 45.0 60.0 75.0 90.0 105.0 !
           120.0 135.0 150.0 165.0 180.0
```

The ShipMo3D graphical user interface (GUI), application ShipMo3D30.exe, can be used for running all ShipMo3D applications. The GUI program assists with input data preparation and interactive viewing of results.

4 Coordinate Systems

ShipMo3D uses both earth-fixed and translating earth coordinate systems. Figure 1 shows a ship in an earth-fixed coordinate system. The location of the ship centre of gravity in the horizontal plane is given by x^f, y^f. The direction ν of incident waves is given using a "from" convention, with 0° representing waves from north and 90° representing waves from east. Ship heading χ is given using a "to" convention, with 0° representing the ship heading north and 90° representing the ship heading east.

A translating earth coordinate system, shown in Figure 2, is used for representing ship motions in heave, roll, and pitch, and also for frequency domain applications. Heave η_3 is the vertical displacement (+ upward) of the ship centre of gravity relative to its position when the ship is in calm water; thus, the mean heave is typically near zero. Ship pitch η_5 of a freely maneuvering ship is given relative to its position at heading χ, and ship roll η_4 is given relative to the instantaneous heading angle χ and pitch angle η_5 of the moving ship.

Wave diffraction computations using SM3DRadDif and seakeeping computations using SM3DSeakeepRegular and SM3DSeakeepRandom are based on relative sea direction β_s as shown in Figure 3 (180° for head seas, 90° for seas from port). Relative sea direction is related to ship heading and wave heading by:

$$\beta_s \;=\; \nu \;+\; 180^\circ \;-\; \chi \tag{4}$$

For deflections of rudders, ShipMo3D uses a convention of positive deflection when counter-clockwise as viewed from inside the hull. Consequently, positive deflection of a typical ship rudder pointing downward will cause a ship to turn starboard.

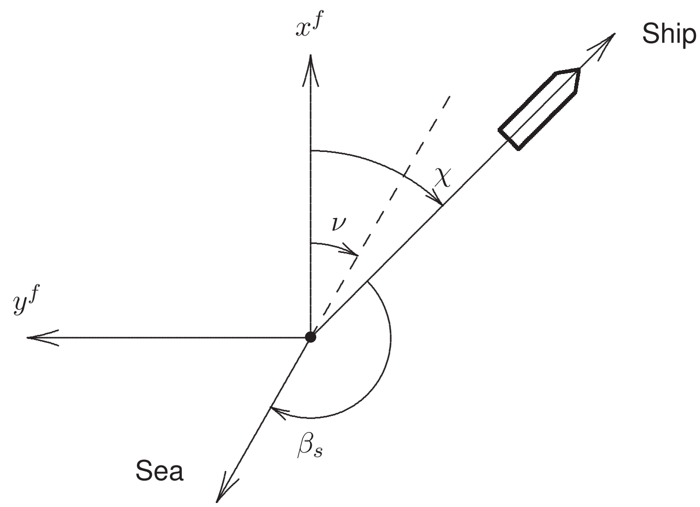

Figure 1: *Earth-Fixed Coordinate System*

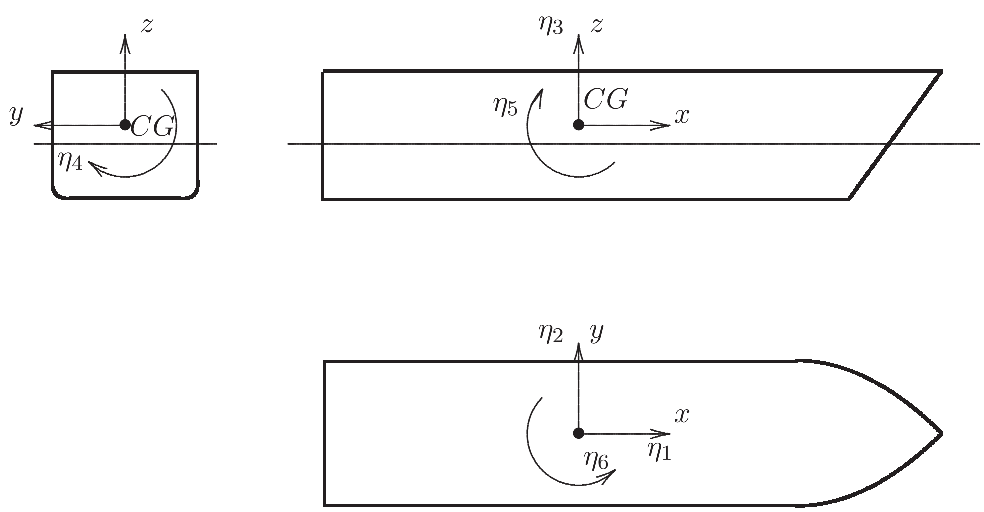

Figure 2: *Translating Earth Coordinate System*

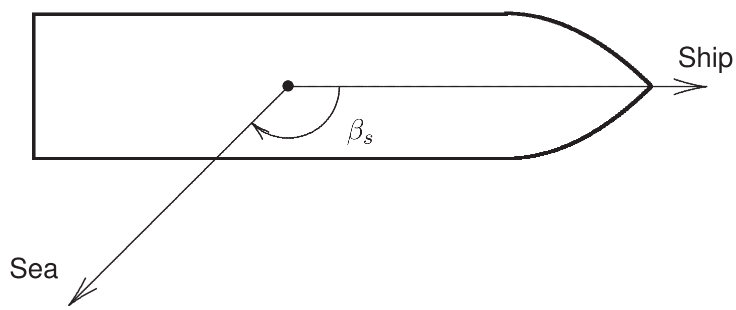

Figure 3: *Sea Direction Relative to Ship*

5 Building of Seaway Model – SM3DBuildSeaway

Table 2 gives a summary of application SM3DBuildSeaway, which creates a regular or random seaway in earth-fixed coordinates. Figure 4 shows a sample view of a long-crested random seaway produced by SM3DBuildSeaway.

Table 2: *SM3DBuildSeaway Summary*

Purpose:	Creates a regular or random seaway in fixed-earth coordinates.
Run time:	Several seconds.
Default input file:	buildSeaway3.inp
Default output file:	buildSeaway3.out
Input format and sample files:	Annex A

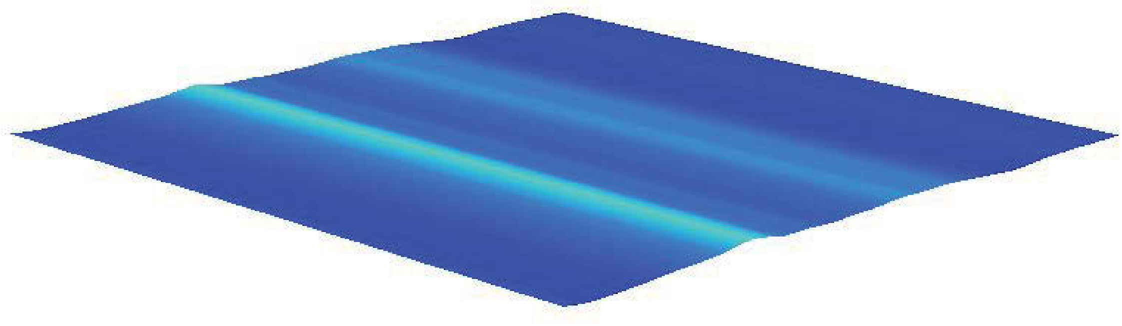

Figure 4: *Long-crested Seaway with Bretschneider Spectrum, Sea State 5*

SM3DBuildSeaway represents random seaways using superposition of a number of sinusoidal wave components. Both unidirectional and multidirectional random seaways can be produced. For a random seaway, the range of wave frequencies should be sufficient to encompass almost all energy within the wave spectrum. For ocean wave spectra, a frequency range of 0.2 – 2.0 rad/s is recommended.

5.1 Wave Spectra for Random Seaways

SM3DBuildSeaway can produce random seaways based on input wave spectra. Reference 4 describes modelling of seaways in detail. Wave spectra available in SM3DBuildSeaway are provided here for reference. For point wave spectra (i.e., non-directional spectra), ShipMo3D uses units of $m^2/(rad/s)$ for spectral density. For directional

wave spectra, ShipMo3D uses units of $m^2/(rad/s)/deg$ for directional spectral density.

5.1.1 Bretschneider Spectrum

The Bretschneider spectrum is the most commonly used model of point wave spectra in the open ocean. Based on the 15th International Towing Tank Conference (ITTC) [19], the formulation for the Bretschneider spectrum is:

$$S_{\omega_I}(\omega_I) \;=\; \frac{486.0\; H_s^2}{T_p^4\; \omega_I^5} \;\exp\left[\frac{-1948.2}{T_p^4\; \omega_I^4}\right] \tag{5}$$

where ω_I is wave frequency, and H_s is significant wave height. The above spectrum is defined in terms of peak wave period T_p. For a Bretschneider spectrum, the following relations exist with the average and zero-crossing wave periods:

$$T_1 \;=\; 0.773\; T_p \tag{6}$$

$$T_z \;=\; 0.710\; T_p \tag{7}$$

5.1.2 Three Parameter JONSWAP Spectrum

The JONSWAP spectrum models relatively high-peaked point spectra typically encountered in fetch-limited regions [19]. The JONSWAP spectrum is obtained by multiplying the Bretschneider spectrum by a peak enhancement factor accounting for fetch-limited conditions, giving the following [20]:

$$S_{\omega_I}(\omega_I) \;=\; \alpha^*\; H_s^2\, \frac{\omega_p^4}{\omega_I^5} \;\exp\left[-1.25\frac{\omega_p^4}{\omega_I^4}\right] \;\gamma^\kappa \tag{8}$$

$$\kappa \;=\; \exp\left[\frac{-\left(\omega_I-\omega_p\right)^2}{2\sigma^2\omega_p^2}\right] \tag{9}$$

$$\sigma \;=\; \begin{cases} 0.07 & \text{for } \omega_I \;\leq\; \omega_p \\ 0.09 & \text{for } \omega_I \;>\omega_p \end{cases} \tag{10}$$

where ω_p is the peak wave frequency and γ is an input spectral peak parameter. Goda [21] derived the following approximate expression for the normalization term α^*:

$$\alpha^* \;=\; \frac{0.0624}{0.230\; +\; 0.0336\,\gamma\; -\; 0.185/(1.9+\gamma)} \tag{11}$$

The JONSWAP spectrum is often presented as a two parameter spectrum, with the spectral peak parameter γ having a default value of 3.3.

5.1.3 Ochi and Hubble Six Parameter Spectrum

The Ochi and Hubble 6 parameter point spectrum [22] models collinear swell and sea components as follows:

$$S_{\omega_I}(\omega_I) \;=\; \frac{1}{4} \sum_{i=1}^{2} \frac{\left[\left(\frac{4\lambda_i+1}{4}\right)\; \omega_{p-i}^4\right]^{\lambda_i} \;\; h_{s-i}^2 \;\; \exp\left[-\;\left(\frac{4\lambda_i+1}{4}\right)\;\left(\frac{\omega_{p-i}}{\omega_I}\right)^4\right]}{\Gamma(\lambda_i)\;\omega_I^{(4\lambda_i+1)}} \tag{12}$$

where λ_i, h_{s-i}, and ω_{p-i} are the spectral shape parameter, significant wave height, and peak frequency for component i. The term $\Gamma(\lambda_i)$ is the Gamma function with argument λ_i. If only one of the two components is considered and the shape parameter λ_i equals one, then the six parameter spectrum is equivalent to the Bretschneider spectrum.

5.1.4 Bretschneider and JONSWAP Spectrum with Cosine-Squared Spreading Function

A directional wave spectrum can be most easily modelled by multiplying a point spectrum by a directional spreading function as follows:

$$S_{\omega_I,\nu}(\omega_I,\nu) \;=\; S_{\omega_I}(\omega_I)\; G(\nu) \tag{13}$$

where $G(\nu)$ is a directional spreading function. ShipMo3D can apply a cosine-squared spreading function to a Bretschneider or JONSWAP spectrum. The form of the spreading function is as follows:

$$G(\nu) \;=\; \frac{1}{\theta_s}\;\cos^2\left(\frac{\nu\;-\;\overline{\nu}}{\theta_s}\;\frac{\pi}{2}\right) \qquad \text{for } |\nu\;-\;\overline{\nu}| \leq \theta_s \tag{14}$$

$$G(\nu) \;=\; 0 \qquad \text{for } |\nu\;-\;\overline{\nu}| > \theta_s \tag{15}$$

where $\overline{\nu}$ is the principal wave direction and θ_s is the spreading angle in degrees. A spreading angle of 90 degrees is often used for seakeeping computations. The spreading function given in Equation (14) has units of deg^{-1} when the terms ν, $\overline{\nu}$, and θ_s are given in units of degrees. Although Equations (14) and (15) are defined using directions ν and $\overline{\nu}$ based in fixed-earth axes, they can also be easily defined in terms of relative sea direction β_s.

5.1.5 Ten Parameter Directional Spectrum

Directional seas can be most apparent when sea and swell components are similar in magnitude and are approaching from different directions. The ten parameter spectrum developed by Hogben and Cobb [23] is a directional extension of the Ochi and

Hubble six parameter spectrum, with each of the swell and sea components being multiplied by its own directional spreading function as follows:

$$M_i(\nu) \;=\; A(P_i)\,\cos^{2P_i}\left(\frac{\pi}{180^\circ}\,\frac{\nu-\overline{\nu}_i}{2}\right)\ \text{for } i=1,2 \tag{16}$$

where P_i and $\overline{\nu}_i$ are the directional spreading parameter and mean direction (from) for component i. The normalization factor $A(P_i)$ is expressed as:

$$A(P_i) \;=\; \frac{2^{(2P_i-1)}\,\Gamma^2(P_i+1)}{180^\circ\,\Gamma(2P_i+1)} \qquad i=1,2 \tag{17}$$

where $\Gamma(2P_i+1)$ is the Gamma function with argument $2P_i+1$. The above equations are based on parameters ν and $\overline{\nu_i}$ being in units of degrees, and each spreading function $M_i(\nu)$ having units of degrees^{-1}.

6 Motions of Freely Maneuvering Ship in a Seaway – SM3DFreeMo

Table 3 gives a summary of application SM3DFreeMo for simulating motions in the time domain of a freely maneuvering ship.

Table 3: *SM3DFreeMo Summary*

Purpose:	Simulates motions in the time domain of a freely maneuvering ship.
Run time:	Typically faster than real-time.
Default input file:	freeMo3.inp
Default output file:	freeMo3.out
Input format and sample files:	Annex B
Other required input:	A ship model file created by SM3DBuildShip [1]. A seaway model file created by SM3DBuildSeaway if the ship is in waves.

7 Ship Seakeeping in a Regular Seaway – SM3DSeakeepRegular

Table 4 gives a summary of application SM3DSeakeepRegular.

Table 4: *SM3DSeakeepRegular Summary*

Purpose:	Computes ship motions in the frequency domain for a ship in regular waves.
Run time:	A few seconds.
Default input file:	seakeepRegular3.inp
Default output file:	seakeepRegular3.out
Input format and sample files:	Annex C
Other required input:	A ship model file created by SM3DBuildShip [1].

8 Ship Seakeeping in a Random Seaway with Principal Direction Given Relative to the Ship – SM3DSeakeepRandom

Table 5 gives a summary of application SM3DSeakeepRandom.

Table 5: *SM3DSeakeepRandom Summary*

Purpose:	Computes ship motions in the frequency domain for a ship in random waves with a principal sea direction (i.e., long-crested waves or waves with a cosine-squared spreading function).
Run time:	A few seconds.
Default input file:	seakeepRandom3.inp
Default output file:	seakeepRandom3.out
Input format and sample files:	Annex D
Other required input:	A ship model file created by SM3DBuildShip [1].

9 Ship Seakeeping in a Fixed Seaway with Ship Heading Given Relative to Earth-Fixed Axes – SM3DSeakeepSeaway

Table 6 gives a summary of application SM3DSeakeepSeaway.

Table 6: *SM3DSeakeepSeaway Summary*

Purpose:	Computes ship motions in the frequency domain for a ship in an earth-fixed seaway, with ship heading given relative to earth-fixed axes.
Run time:	Ranging from a few seconds to several minutes.
Default input file:	seakeepSeaway3.inp
Default output file:	seakeepSeaway3.out
Input format and sample files:	Annex E
Other required input:	A ship model file created by SM3DBuildShip [1].

10 Ship Seakeeping in a Fixed Seaway Using Previously Computed Ship Motion RAOs – SM3DSeakeepSeawayFromRaos

Table 7 gives a summary of application SM3DSeakeepSeawayFromRaos.

Table 7: *SM3DSeakeepSeawayFromRaos Summary*

Purpose:	Computes ship motions in the frequency domain for a ship in an earth-fixed seaway, with ship heading given relative to earth-fixed axes. Previously computed ship motion response amplitude operators are used, giving fast execution.
Run time:	A few seconds.
Default input file:	seakeepSeawayFromRaos3.inp
Default output file:	seakeepSeawayFromRaos3.out
Input format and sample files:	Annex F
Other required input:	A database of ship RAOs created by SM3DSeakeepRegular, SM3DSeakeepRandom, or SM3DSeakeepSeaway.

11 Time Series of Ship Motions from Response Amplitude Operators – SM3DTimeSeriesFromRaos

Table 8 gives a summary of application SM3DTimeSeriesFromRaos.

Table 8: *SM3DTimeSeriesFromRaos Summary*

Purpose:	Computes ship motions in the time domain for a ship with quasi-steady speed and heading
Run time:	A few seconds.
Default input file:	timeSeriesFromRaos3.inp
Default output file:	timeSeriesFromRaos3.out
Input format and sample files:	Annex G
Other required input:	A database of ship RAOs created by SM3DSeakeepRegular, SM3DSeakeepRandom, or SM3DSeakeepSeaway. A seaway model created by SM3DBuildSeaway.

12 Inputs for Rudder and Azimuthing Propeller Autopilots

For the motion prediction applications SM3DFreeMo, SM3DSeakeepRegular, SM3D-SeakeepRandom, and SM3DSeakeepSeaway, the user can specify input autopilot settings. If autopilot settings are not given as input for these applications, then default settings are used from the ship model produced by SM3DBuildShip [1].

For time domain simulation, ShipMo3D models a proportional-integral-derivative (PID) autopilot. If the rudder is operating in autopilot mode, then the rudder command angle is determined by input autopilot gains and ship motions in earth-fixed axes:

$$\delta_C^{rudder} = \sum_{j=1}^{6} \left[k_{\delta j}^P \left(\eta_j^f - \eta_{Cj}^f \right) + k_{\delta j}^I \int_0^{\tau_{max}^{rudder}} \left(\eta_j^f (t - \tau) - \eta_{Cj}^f \right) d\tau + k_{\delta j}^D \dot{\eta}_j^f \right] \quad (18)$$

where $k_{\delta j}^P$ is the proportional gain for mode j, η_j^f is the motion displacement in earth-fixed axes for mode j, η_{Cj}^f is the command motion displacement for mode j, $k_{\delta j}^I$ is the integral gain for mode j, τ_{max}^{rudder} is the integration duration, t is the current time, τ is the time delay for integration, $k_{\delta j}^D$ is the derivative gain for mode j, and $\dot{\eta}_j^f$ is the motion velocity in earth-fixed axes for mode j. For frequency domain computations, the integral gains $k_{\delta j}^I$ are assumed to be zero.

For all ShipMo3D user applications, user input autopilot gains are based on earth-fixed coordinates; thus, input yaw gains are based on yaw being positive clockwise when viewed from above. For modelling of a conventional downward rudder using ShipMo3D, the input yaw displacement gain and yaw velocity gain will typically have values equal to or less than zero. Note that input surge and sway gains should be set to zero.

13 Inputs for Frequency Domain Ship Motion Predictions in Random Seas

This section gives background information that is useful when running the applications SM3DSeakeepRandom, SM3DSeakeepSeaway, and SM3DSeakeepSeawayFromRaos for predicting motions in random seas.

13.1 Wave Spectra

Section 5 of this report, which describes input for SMB3DBuildSeaway, provides useful information on wave spectra that can be used as input for frequency domain predictions.

13.2 Motion-Induced Interruptions

The frequency domain applications SM3DSeakeepRandom, SM3DSeakeepSeaway and SM3DSeakeepSeawayFromRaos can compute ship-referenced forces and estimate the incidence of motion-induced interruptions (MIIs) at seakeeping positions. The incidence of MIIs, which can be tipping or sliding events, is estimated using tipping or sliding estimator functions which include the contributions of vertical forces as well as the forces parallel to the deck. Detailed treatment of MIIs is given in References 24 and 25.

The incidence of tipping events for a person or object depends upon the tipping coefficient s/h, where s is the half stance width and h is the height above deck of the centre of gravity, as shown in Figure 5. The tipping coefficient is usually dependent upon the direction of tipping. To evaluate the incidence of sliding events, the tipping coefficient s/h can be replaced by the static coefficient of friction μ_s. Table 9 gives representative tipping and sliding coefficients from Reference 25 and unpublished data. The wide range of friction coefficients suggests the incidence of sliding can vary greatly, depending on sliding surface conditions. Because the static coefficient of friction for a person is usually greater than the tipping coefficient, a person will usually tip more easily than slide. Table 10, reproduced from Reference 24, gives risk levels associated with motion-induced interruptions (MIIs).

13.3 Slamming Pressures and Forces

Slamming calculations within ShipMo3D are based largely on the work of Ochi and Motter [26] and Stavovy and Chuang [27]. The maximum slam pressure at the keel

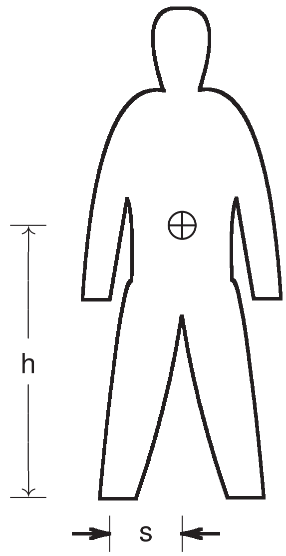

Figure 5: *Model for Person Standing on Deck*

Table 9: *Representative Tipping and Sliding Coefficients*

Tipping in the forward direction	0.17
Tipping in the sideways direction	0.25
Sliding, person standing on dry deck	0.7
Sliding, chair on interior floor	0.19
Sliding, helicopter for various deck conditions	0.2 - 0.8

Table 10: *MII Risk Levels*

Risk Level	MIIs per Minute
1. possible	0.1
2. probable	0.5
3. serious	1.5
4. severe	3.0
5. extreme	5.0

is related to a sectional slamming pressure coefficient as follows:

$$p_{max} = \frac{1}{2}\,\rho\,V_r^2 \times \text{slamPressureCo} \tag{19}$$

where ρ is water density, V_r is the relative impact velocity upon impact, and slamPressureCo is the slamming pressure coefficient, which can be given as an input parameter or computed based on input geometry. For calculating the slamming force per unit length, ShipMo3D uses the assumption from Reference 26 that the sectional slamming pressure goes from a maximum value at the keel to zero at a specified elevation above the keel, as illustrated in Figure 6. The elevation of zero slam pressure is typically taken as being $T_x/10$ above the keel, where T_x is the sectional draft. The sectional slamming force per unit length is computed using an effective slamming pressure width as follows:

$$F_{max} = p_{max} \times \text{slamForceWidth} \tag{20}$$

where slamForceWidth is given as an input parameter or computed based on sectional geometry.

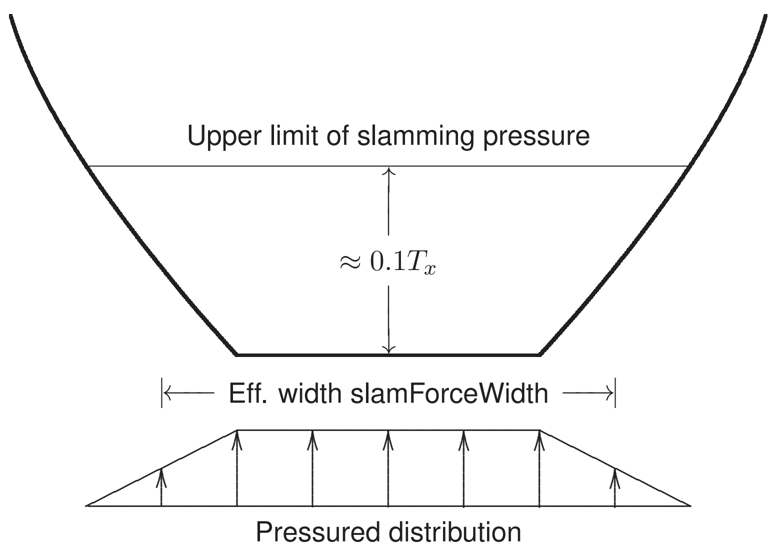

Figure 6: *Assumed Slamming Pressure Distribution for Sectional Force Computation*

The user can provide input values for the slamming pressure coefficient and effective force width. Alternatively, ShipMo3D can compute the pressure coefficient and effective width based on the lower sectional geometry provided by the user. If the geometry is input as a wedge as shown in Figure 7, then ShipMo3D uses a fit to experimental data given by Stavovy and Chuang for computing the form factor. Stavovy and Chuang's method has been slightly modified to impose a form factor limit of 100,

which affects sections with deadrise angles smaller than 6 degrees. Using the assumed pressure distribution of Figure 6, the effective pressure width for a wedge is:

$$\text{slamForceWidth} = \frac{\text{slamForceHeight}}{\tan(\text{deadRiseDeg})} \tag{21}$$

where slamForceHeight is the height above the keel at which the slamming pressure goes to zero and deadRiseDeg is the deadrise angle.

If the user inputs the geometry near the keel as offsets, then ShipMo3D uses Ochi and Motter's method to compute slamming form coefficients. Figure 8 illustrates input offsets for computing the slamming form factor.

Experimental results indicate that slamming pressures can be highly sensitive to ship section geometry, size of area of pressure measurement, and structural properties of impact area; thus, predicted slamming pressures and forces should be considered to be only approximate values. Published values indicate that slamming form factors can lie within an extremely large range of between less than 1 and greater than 300; however, the actual slamming coefficient for a ship section in a seaway will rarely exceed 30. Slamming coefficients computed using input offsets near the keel and Ochi and Motter's method are likely smaller in magnitude and more realistic than values computed for a wedge based on Stavovy and Chuang. Figure 9 shows slamming coefficients predicted by ShipMo3D for wedge sections based on Stavovy and Chuang's method and Ochi and Motter's method. For wedge sections with large deadrise angles (greater than 50 degrees), Ochi's method fails to provide results because of numerical problems.

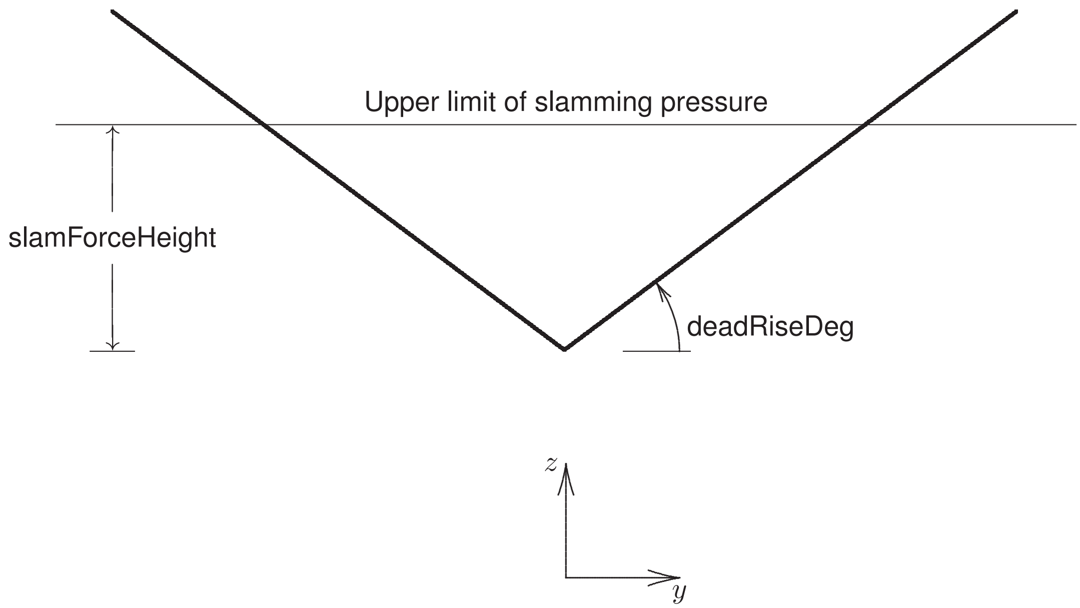

Figure 7: *Input Wedge Geometry for Computing Slamming Form Factor*

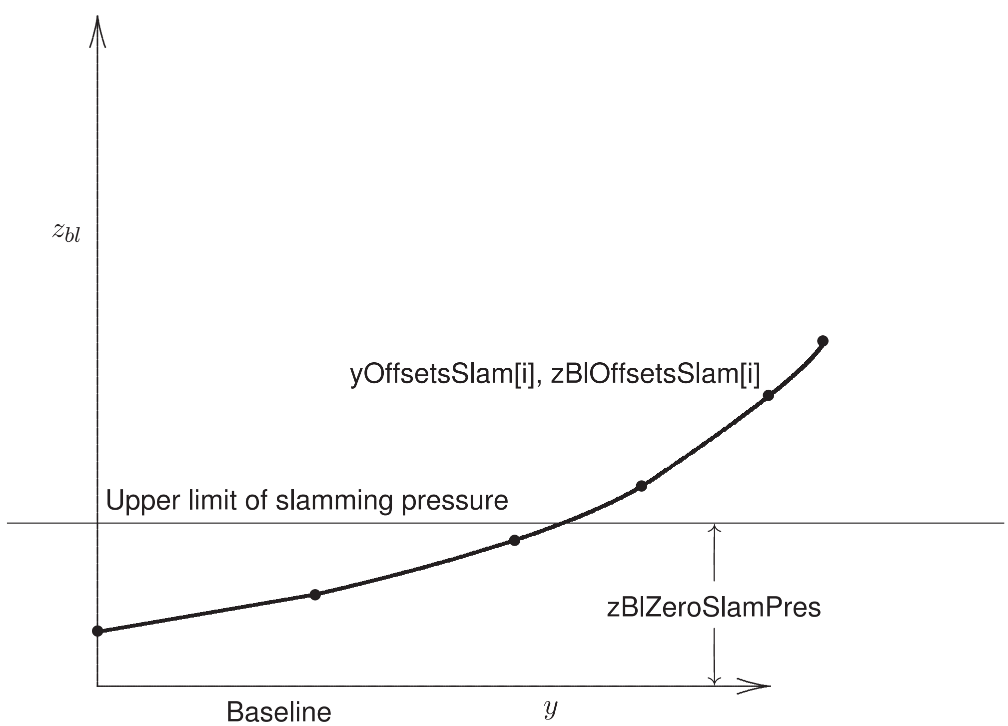

Figure 8: *Input Sectional Offsets Near Keel for Computing Slamming Form Factor*

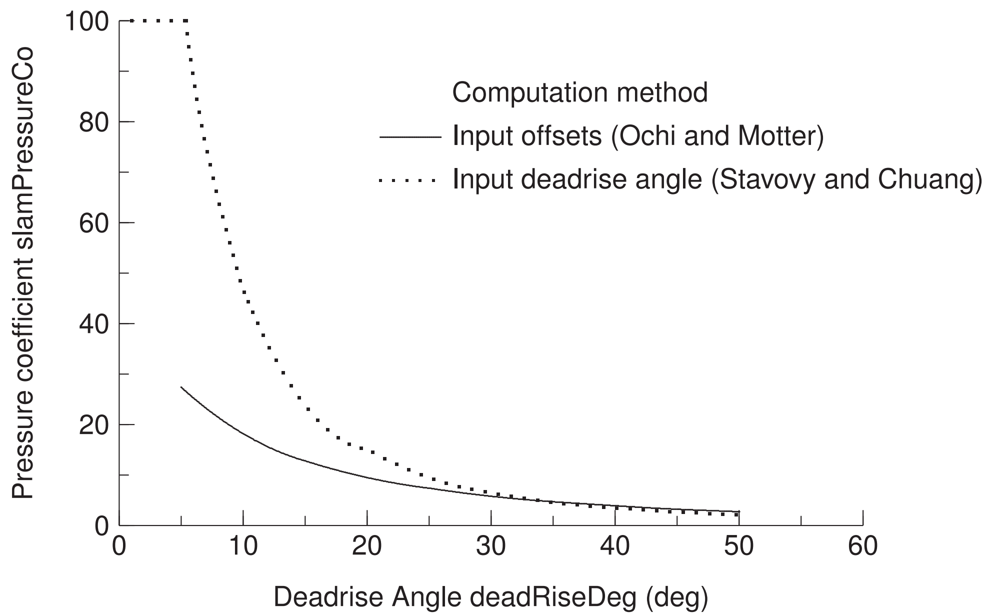

Figure 9: *Slamming Pressure Coefficients for Wedge Sections*

14 Conclusions

ShipMo3D Version 3.0 includes applications for predicting ship motions in the time and frequency domains. A separate user manual [1] describes development of ship models for input into ship motion predictions.

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Symbols and Abbreviations

$A(P_i)$	normalization factor for ten parameter spectral component i
F_{max}	maximum slamming force
$G(\nu)$	directional wave spectral spreading function
H_s	significant wave height
h	height above deck of the person or object centre of gravity
h_{s-i}	significant wave height for spectral component i
$k^D_{\delta j}$	autopilot derivative (velocity) gain for mode j
$k^I_{\delta j}$	autopilot integral gain for mode j
$k^P_{\delta j}$	autopilot proportional (displacement) gain for mode j
MII	motion-induced interruption
$M_i(\nu)$	spreading function for ten parameter spectrum component i
P_i	spreading parameter for ten parameter spectrum component i
p_{max}	maximum slamming pressure
RAO	response amplitude operator
RMS	root mean square
$S_{\omega_I}(\omega_I)$	point wave spectral density
$S_{\omega_I,\nu}(\omega_I,\nu)$	directional wave spectral density
s	half stance width for computing MIIs
T_p	peak wave period
T_x	sectional draft
T_z	zero-crossing period
T_1	average wave period
V_r	relative vertical velocity
x^f, y^f	horizontal plane coordinates in earth-fixed axes
α^*	JONSWAP spectrum normalization term
β_s	sea direction relative to ship
$\Gamma(X)$	Gamma function with argument X
γ	spectral peak enhancement parameter
δ^{rudder}	rudder deflection angle
ζ_δ	rudder nondimensional damping response constant
η_j	displacement in translating earth axes for mode j
η^f_j	displacement in earth-fixed axes for mode j
η^f_{Cj}	command displacement in earth-fixed axes for mode j

θ_s	spreading angle for cosine squared spectral spreading
κ	JONSWAP spectrum exponent
λ_i	spectral shape parameter for spectral component i
μ_s	static coefficient of friction
ν	wave direction (from) in earth-fixed axes
$\overline{\nu}$	mean wave direction (from) in earth-fixed axes
$\overline{\nu}_i$	mean wave direction (from) for spectral component i
ρ	water density
σ	standard deviation (also RMS) or JONSWAP spectrum parameter
τ_{max}^{rudder}	rudder autopilot integration duration
χ	ship heading (to) in earth-fixed axes
ω_I	incident wave frequency
ω_p	peak wave frequency
ω_{p-i}	peak wave frequency for spectral component i
ω_δ	rudder response natural frequency

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Annex A: Files for Building a Seaway with SM3DBuildSeaway3

A.1 Format of Input Seaway File for SM3DBuildSeaway3

Record (1), Beginning Record

"begin SM3DBuildSeaway3"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText (character string)

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"end note" (1 character string with 2 words)

Record (4), Output Seaway File Name

"seawayFileName", seawayFileName (2 character strings)

"seawayFileName"	Record tag.
seawayFileName	Name of output seaway file in .NET XML serialization format.

Record (5), Water Density

"waterDensity", waterDensity (1 character string, 1 float)

"waterDensity"	Record tag.
waterDensity	Water density (kg/m^3).

Record (6), Time Series Sampling Parameters

This record is optional. If this record is omitted then default values are used.

"sampleParams", tDuration, tInterval (1 character string, 2 floats)

"sampleParams"	Record tag.
tDuration	Duration of seaway for sample statistics (default 3600.0 s).
tInterval	Time interval for sample statistics (default 0.1 s).

Record (7), Seaway Option

"seawayOption", seawayOption (2 character strings)

"seawayOption"	Record tag.
seawayOption	Seaway option. Regular - Regular waves. UniSpectrum - Unidirectional seaway based on input spectrum. BiSpectrum - Bidirectional seaway based on 2 unidirectional input spectra. CosSpectrum - Directional seaway based on a point spectrum and a cosine-squared directional spreading function. DirSpectrum - Directional seaway based on input spectrum. ComponentRandom - Seaway consisting of multiple input wave components, most commonly used to represent a random seaway. Wave component phases are randomly generated. ComponentPhase - Seaway consisting of multiple input wave components, including wave component phases.

Record (8), Beginning of Regular Seaway

Records (8) to (8c) are required if seawayOption is set to Regular in Record (7).

"begin regularSeaway" (1 character string with 2 words)

Record (8a), Regular Seaway Parameters

This record is required if seawayOption in Record (7) is set to Regular.

"regularParam", waveHeadingDeg, waveFreq, waveAmp, phaseDeg, (1 character string, 4 floats)

"regularParam"	Record tag.
waveHeadingDeg	Wave direction (from, degrees). 0° for waves from north, and 90° for waves from east.
waveFreq	Incident wave frequency (rad/s).
waveAmp	Incident wave amplitude (m).
phaseDeg	Phase of wave crest at $x^f = 0.0, y^f = 0.0$ (degrees).

Record (8b), Regular Seaway Nonlinear Option

This record can optionally be used if seawayOption in Record (7) is set to Regular. If this record is not used, then Stokes second-order theory is used.

"regNonlinearOption", regNonlinearOption (2 character strings)

"regNonlinearOption"	Record tag.
regNonlinearOption	Option for modelling wave nonlinearities:
	StokesSecond - Waves are modelled using Stokes second-order theory (default).
	Wheeler - Waves are modelled using Wheeler stretching.
	Linear - Waves are modelled using linear theory.

Record (8c), End of Regular Seaway

This record is required if seawayOption in Record (7) is set to Regular.

"end regularSeaway" (1 character string with 2 words)

Record (9), Beginning of Unidirectional Seaway from Input Spectrum

Records (9) to (9g) are required if seawayOption is set to UniSpectrum in Record (7).

"begin uniSpectrumSeaway" (1 character string with 2 words)

Record (9a), Wave Frequency Range

One of Records (9a) or (9b) is required if seawayOption in Record (7) is set to UniSpectrum.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc, randomIncOption, waveFreqSeed (1 character string, 3 floats, 1 character string, 1 integer)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum wave frequency (rad/s).
waveFreqMax	Maximum wave frequency (rad/s).
waveFreqInc	Wave frequency increment (rad/s).
randomIncOption	Option for random wave frequency increment:
	RandomInc - Intermediate wave frequencies (i.e., those other than the minimum and maximum) are adjusted by randomly generated increments rounded to 6 decimal places. This option is useful for avoiding periodic repetition of simulated seaways.
	UniformInc - The wave frequency increment between components is always waveFreqInc.
waveFreqSeed	Integer seed number for adjusting wave frequencies if randomIncOption is set to RandomInc.

Record (9b), Wave Frequencies

One of Records (9a) or (9b) is required if seawayOption in Record (7) is set to UniSpectrum.

"waveFreqs", waveFreqs (1 character string, array of floats)

"waveFreqs"	Record tag.
waveFreqs	Array of increasing wave frequencies (rad/s)

Record (9c), Wave Phase Seed Number

This record can be optionally used if seawayOption in Record (7) is set to UniSpectrum. If this record is omitted, then a default value will be used.

"phaseSeed", phaseSeed (1 character string, 1 integer)

"phaseSeed"	Record tag.
phaseSeed	Integer seed number (default 1001).

Record (9d), Relative Wave Energy Threshold

This record can be optionally used if seawayOption in Record (7) is set to UniSpectrum. If this record is omitted, then a default value will be used.

"deleteRelThreshEnergy", deleteRelThreshEnergy (1 character string, 1 real)

"deleteRelThreshEnergy"	Record tag.
deleteRelThreshEnergy	Threshold for fraction of wave energy of a modelled seaway component (default 10^{-6}). If the relative energy of a seaway component is below the threshold, then the component is removed. This variable is used to avoid simulating wave spectral components with negligible wave energy.

Record (9e), Wave Heading

This record is required if seawayOption in Record (7) is set to UniSpectrum.

"waveHeading", waveHeadingFromDeg (1 character string, 1 real)

"waveHeading"	Record tag.
waveHeadingFromDeg	Wave direction ν (from, degrees). 0° for waves from north, and 90° for waves from east.

Record (9f), Unidirectional Wave Spectrum Option

This record is required if seawayOption in Record (7) is set to UniSpectrum.

"uniSpectrumOption", uniSpectrumOption (2 character strings)

"uniSpectrumOption"	Record tag.
uniSpectrumOption	Unidirectional wave spectrum option: Bretschneider - Random seaway based on Bretschneider wave spectrum. JONSWAP - Random seaway based on JONSWAP wave spectrum. OchiHubble - Random seaway based on Ochi and Hubble six parameter wave spectrum Input - Random seaway based on user-input wave spectrum.

Record (9f1), Unidirectional Bretschneider Spectrum Seaway Parameters

This record is required if uniSpectrumOption in Record (9f) is set to Bretschneider.

"BretParam", hs, tp (1 character string, 2 floats)

"BretParam"	Record tag.
hs	Significant wave height (m).
tp	Peak wave period (s).

Record (9f2), Unidirectional JONSWAP Spectrum Seaway Parameters

This record is required if uniSpectrumOption in Record (9f) is set to JONSWAP.

"JONSWAPParam", hs, tp, peakEnhance (1 character string, 3 floats)

"JONSWAPParam"	Record tag.
hs	Significant wave height (m).
tp	Peak wave period (s).
peakEnhance	Peak enhancement factor. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (9f3), Unidirectional Ochi Hubble Spectrum Parameters

This record is required if uniSpectrumOption in Record (9f) is set to OchiHubble.

"OchiHubbleParam", waveHeadingFromDeg, hs1, freqPeak1, spectralShape1, hs2, freqPeak2, spectralShape2 (1 character string, 6 floats)

"OchiHubbleParam"	Record tag.
hs1	Significant wave height h_{s-1} of wave system 1 (m).
freqPeak1	Peak wave frequency ω_{p-1} of wave system 1 (rad/s).
spectralShape1	Spectral shape factor λ_1 of wave system 1.
hs2	Significant wave height h_{s-2} of wave system 2 (m).
freqPeak2	Peak wave frequency ω_{p-2} of wave system 2 (rad/s).
spectralShape2	Spectral shape factor λ_2 of wave system 2.

Record (9f4), Unidirectional Input Spectrum Wave Frequencies

This record is required if uniSpectrumOption in Record (9f) is set to Input.

"inputWaveFreqs", inputWaveFreqs (1 character string, array of floats)

"inputWaveFreqs"	Record tag.
inputWaveFreqs	Wave frequencies ω_I for input energy densities (rad/s).

Record (9f5), Unidirectional Input Spectrum Energy Densities

This record is required if uniSpectrumOption in Record (9f) is set to Input.

"inputEnergyDensities", inputEnergyDensities (1 character string, array of floats)

"inputEnergyDensities"	Record tag.
inputEnergyDensities	Wave spectrum energy densities $S_{\omega_I}(\omega_I)$ (m^2/(rad/s)) corresponding to wave frequencies of Record (9f4).

Record (9g), End of Unidirectional Seaway from Input Spectrum

This record is required if seawayOption in Record (7) is set to UniSpectrum.

"end uniSpectrumSeaway" (1 character string with 2 words)

Record (10), Beginning of Bidirectional Seaway from Input Spectrum

Records (10) to (10f) are required if seawayOption is set to BiSpectrum in Record (7).

"begin biSpectrumSeaway" (1 character string with 2 words)

Record (10a), Wave Frequency Range

One of Records (10a) or (10b) is required if seawayOption in Record (7) is set to BiSpectrum.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc, randomIncOption, waveFreqSeed (1 character string, 3 floats, 1 character string, 1 integer)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum wave frequency (rad/s).
waveFreqMax	Maximum wave frequency (rad/s).
waveFreqInc	Wave frequency increment (rad/s).
randomIncOption	Option for random wave frequency increment.
	RandomInc - Intermediate wave frequencies (i.e., those other than the minimum and maximum) are randomly adjusted, with rounding to 6 decimal places. This option is useful for avoiding periodic repetition of simulated seaways.
	UniformInc - The wave frequency increment between components is always waveFreqInc.
waveFreqSeed	Integer seed number for adjusting wave frequencies if randomIncOption is set to randomInc.

Record (10b), Wave Frequencies

One of Records (10a) or (10b) is required if seawayOption in Record (7) is set to BiSpectrum.

"waveFreqs", waveFreqs (1 character string, array of floats)

"waveFreqs"	Record tag.
waveFreqs	Array of increasing wave frequencies (rad/s)

Record (10c), Wave Phase Seed Number

This records can be optionally used if seawayOption in Record (7) is set to BiSpectrum. If this record is omitted, then a default will be used.

"phaseSeed", phaseSeed (1 character string, 1 integer)

"phaseSeed"	Record tag.
phaseSeed	Integer seed number (default 1001).

Record (10d), Relative Wave Energy Threshold

This record can be optionally used if seawayOption in Record (7) is set to BiSpectrum. If this record is omitted, then a default value will be used.

"deleteRelThreshEnergy", deleteRelThreshEnergy (1 character string, 1 float)

"deleteRelThreshEnergy"	Record tag.
deleteRelThreshEnergy	Threshold for fraction of wave energy of a modelled seaway component (default 10^{-6}). If the relative energy of a seaway component is below the threshold, then the component is removed. This variable is used to avoid simulating wave spectral components with negligible wave energy.

Record (10e), Bidirectional Wave Spectrum Option

This record is required if seawayOption in Record (7) is set to BiSpectrum.

"biSpectrumOption", biSpectrumOption (2 character strings)

"biSpectrumOption"	Record tag.
biSpectrumOption	Bidirectional wave spectrum option: BiBretschneider - Random seaway based on Bretschneider wave spectrum. BiJONSWAP - Random seaway based on JONSWAP wave spectrum.

Record (10e1), Bidirectional Bretschneider Spectrum Seaway Parameters

This record is required if biSpectrumOption in Record (10e) is set to Bretschneider.

"biBretParam", waveHeadingDeg1, hs1, tp1, waveHeadingDeg2, hs2, tp2 (1 character string, 6 floats)

"biBretParam"	Record tag.
waveHeadingDeg1	Principle wave direction of first wave system (from, degrees). 0° for waves from north, and 90° for waves from east.
hs1	Significant wave height of first wave system (m).
tp1	Peak wave period of first wave system (s).
waveHeadingDeg2	Principle wave direction of second wave system (from, degrees). 0° for waves from north, and 90° for waves from east.
hs2	Significant wave height of second wave system (m).
tp2	Peak wave period of second wave system (s).

Record (10e2), Bidirectional JONSWAP Spectrum Seaway Parameters

This record is required if biSpectrumOption in Record (10e) is set to JONSWAP.

"biJONSWAPParam", waveHeadingDeg1, hs1, tp1, peakEnhance1, waveHeadingDeg2, hs2, tp2, peakEnhance2 (1 character string, 8 floats)

"biJONSWAPParam"	Record tag.
waveHeadingDeg1	Principle wave direction of first wave system (from, degrees). 0° for waves from north, and 90° for waves from east.
hs1	Significant wave height of first wave system (m).
tp1	Peak wave period of first wave system (s).
peakEnhance1	Peak enhancement factor of first wave system. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.
waveHeadingDeg2	Principle wave direction of second wave system (from, degrees). 0° for waves from north, and 90° for waves from east.
hs2	Significant wave height of second wave system (m).
tp2	Peak wave period of second wave system (s).
peakEnhance2	Peak enhancement factor of second wave system. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (10f), End of Bidirectional Seaway from Input Spectrum

This record is required if seawayOption in Record (7) is set to BiSpectrum.

"end biSpectrumSeaway" (1 character string with 2 words)

Record (11), Beginning of Seaway from Spectrum with Cosine-squared Spreading

Records (11) to (11j) are required if seawayOption is set to cosSpectrum in Record (7).

"begin cosSpectrumSeaway" (1 character string with 2 words)

Record (11a), Wave Frequency Range

One of Records (11a) or (11b) is required if seawayOption in Record (7) is set to cosSpectrum.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc, randomIncOption, waveFreqSeed (1 character string, 3 floats, 1 character string, 1 integer)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum wave frequency (rad/s).
waveFreqMax	Maximum wave frequency (rad/s).
waveFreqInc	Wave frequency increment (rad/s).
randomIncOption	Option for random wave frequency increment. RandomInc - Intermediate wave frequencies (i.e., those other than the minimum and maximum) are adjusted by randomly generated increments rounded to 6 decimal places. This option is useful for avoiding periodic repetition of simulated seaways. UniformInc - The wave frequency increment between components is always waveFreqInc.
waveFreqSeed	Integer seed number for adjusting wave frequencies if randomIncOption is set to randomInc.

Record (11b), Wave Frequencies

One of Records (11a) or (11b) is required if seawayOption in Record (7) is set to cosSpectrum

"waveFreqs", waveFreqs (1 character string, array of floats

"waveFreqs"	Record tag.
waveFreqs	Array of increasing wave frequencies (rad/s)

Record (11c), Wave Heading Range

One of Records (11c) or (11d) is required if seawayOption in Record (7) is set to cosSpectrum.

"waveHeadingRange", waveHeadingMinDeg, waveHeadingMaxDeg, waveHeadingIncDeg (1 character string, 3 floats)

"waveHeadingRange"	Record tag.
waveHeadingMinDeg	Minimum wave heading (deg).
waveHeadingMaxDeg	Maximum wave heading (deg).
waveHeadingIncDeg	Wave heading increment (deg).

Record (11d), Wave Headings

One of Records (11c) or (11d) is required if seawayOption in Record (7) is set to cosSpectrum

"waveHeadings", waveHeadings (1 character string, array of floats)

"waveHeadings"	Record tag.
waveHeadingsDeg	Array of increasing wave headings (deg).

Record (11e), Wave Phase Seed Number

This records can be optionally used if seawayOption in Record (7) is set to cosSpectrum. If this record is omitted, then a default will be used.

"phaseSeed", phaseSeed (1 character string, 1 integer)

"phaseSeed"	Record tag.
phaseSeed	Integer seed number (default 1001).

Record (11f), Relative Wave Energy Threshold

This record can be optionally used if seawayOption in Record (7) is set to cosSpectrum. If this record is omitted, then a default value will be used.

"deleteRelThreshEnergy", deleteRelThreshEnergy (1 character string, 1 real

"deleteRelThreshEnergy"	Record tag.
deleteRelThreshEnergy	Threshold for fraction of wave energy of a modelled seaway component (default 10^{-6}). If the relative energy of a seaway component is below the threshold, then the component is removed. This variable is used to avoid simulating wave spectral components with negligible wave energy.

Record (11g), Mean Wave Heading

This record is required if seawayOption in Record (7) is set to CosSpectrum.

"waveHeadingMean", waveHeadingMeanDeg (1 character string, 1 real)

"waveHeadingMean"	Record tag.
waveHeadingMeanDeg	Mean wave direction ν (from, degrees). 0° for waves from north, and 90° for waves from east.

Record (11h), Wave Spreading Angle

This record is required if seawayOption in Record (7) is set to CosSpectrum.

"spreadAngle", spreadAngleDeg (1 character string, 1 float)

"spreadAngle"	Record tag.
spreadAngleDeg	Directional spreading angle (deg).

Record (11i), Cosine-squared Spreading Wave Spectrum Option

This record is required if seawayOption in Record (7) is set to cosSpectrum.

"cosSpectrumOption", cosSpectrumOption (2 character strings

"cosSpectrumOption"	Record tag.
cosSpectrumOption	Cosine-squared wave spectrum option: CosBretschneider - Random seaway based on Bretschneider wave spectrum with cosine-squared spreading function. CosJONSWAP - Random seaway based on JONSWAP wave spectrum with cosine-squared spreading function.

Record (11i1), Cosine-squared Spreading Bretschneider Spectrum Seaway Parameters

This record is required if cosSpectrumOption in Record (11i) is set to CosBretschneider.

"BretParam", hs, tp (1 character string, 2 floats)

"BretParam"	Record tag.
hs	Significant wave height (m).
tp	Peak wave period (s).

Record (11i2), Cosine-squared Spreading JONSWAP Spectrum Seaway Parameters

This record is required if cosSpectrumOption in Record (11i) is set to CosJONSWAP.

"JONSWAPParam", hs, tp, peakEnhance (1 character string, 3 floats)

"JONSWAPParam"	Record tag.
hs	Significant wave height (m).
tp	Peak wave period (s).
peakEnhance	Peak enhancement factor. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (11j), End of Seaway with from Spectrum with Cosine-squared Spreading

This record is required if seawayOption in Record (7) is set to cosSpectrum.

"end cosSpectrumSeaway" (1 character string with 2 words)

Record (12), Beginning of Directional Seaway from Input Spectrum

Records (12) to (12i) are required if seawayOption is set to dirSpectrum in Record (7).

"begin dirSpectrumSeaway" (1 character string with 2 words)

Record (12a), Wave Frequency Range

One of Records (12a) or (12b) is required if seawayOption in Record (7) is set to dirSpectrum.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc, randomIncOption, waveFreqSeed (1 character string, 3 floats, 1 character string, 1 integer)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum wave frequency (rad/s).
waveFreqMax	Maximum wave frequency (rad/s).
waveFreqInc	Wave frequency increment (rad/s).
randomIncOption	Option for random wave frequency increment. RandomInc - Intermediate wave frequencies (i.e., those other than the minimum and maximum) are adjusted by randomly generated increments rounded to 6 decimal places. This option is useful for avoiding periodic repetition of simulated seaways. UniformInc - The wave frequency increment between components is always waveFreqInc.
waveFreqSeed	Integer seed number for adjusting wave frequencies if randomIncOption is set to randomInc.

Record (12b), Wave Frequencies

One of Records (12a) or (12b) is required if seawayOption in Record (7) is set to dirSpectrum

"waveFreqs", waveFreqs (1 character string, array of floats

"waveFreqs" Record tag.

waveFreqs Array of increasing wave frequencies (rad/s)

Record (12c), Wave Heading Range

One of Records (12c) or (12d) is required if seawayOption in Record (7) is set to dirSpectrum.

"waveHeadingRange", waveHeadingMinDeg, waveHeadingMaxDeg, waveHeadingIncDeg (1 character string, 3 floats)

"waveHeadingRange" Record tag.

waveHeadingMinDeg Minimum wave heading (deg).

waveHeadingMaxDeg Maximum wave heading (deg).

waveHeadingIncDeg Wave heading increment (deg).

Record (12d), Wave Headings

One of Records (12c) or (12d) is required if seawayOption in Record (7) is set to DirSpectrum.

"waveHeadings", waveHeadings (1 character string, array of floats)

"waveHeadings" Record tag.

waveHeadingsDeg Array of increasing wave headings (deg).

Record (12e), Wave Phase Seed Number

This records can be optionally used if seawayOption in Record (7) is set to DirSpectrum. If this record is omitted, then a default will be used.

"phaseSeed", phaseSeed (1 character string, 1 integer)

"phaseSeed" Record tag.

phaseSeed Integer seed number (default 1001).

Record (12f), Relative Wave Energy Threshold

This record can be optionally used if seawayOption in Record (7) is set to DirSpectrum. If this record is omitted, then a default value will be used.

“deleteRelThreshEnergy”, deleteRelThreshEnergy (1 character string, 1 float)

“deleteRelThreshEnergy”	Record tag.
deleteRelThreshEnergy	Threshold for fraction of wave energy of a modelled seaway component (default 10^{-6}). If the relative energy of a seaway component is below the threshold, then the component is removed. This variable is used to avoid simulating wave spectral components with negligible wave energy.

Record (12g), Multidirectional Wave Spectrum Option

This record is required if seawayOption in Record (7) is set to DirSpectrum.

“dirSpectrumOption”, dirSpectrumOption (2 character strings)

“dirSpectrumOption”	Record tag.
dirSpectrumOption	Multidirectional wave spectrum option: TenParameter - Random seaway based on ten parameter wave spectrum. EndecoWaveBuoy - Random seaway based on directional spectrum from Endeco 956 or 1156 wave buoy. InputDir - Input directional spectrum. The format of the spectrum is given in Annex A.2.

Record (12g1), Multidirectional Ten Parameter Spectrum Seaway Parameters

This record is required if dirSpectrumOption in Record (12g) is set to TenParameter.

"tenParamParam", hs1, freqPeak1, spectralShape1, waveHeadingMeanDeg1, dirSpreadExp1, hs2, freqPeak2, spectralShape2, waveHeadingMeanDeg2, dirSpreadExp2 (1 character string, 10 floats)

"tenParamParam"	Record tag.
hs1	Significant wave height of wave system 1 (m).
freqPeak1	Peak wave frequency of wave system 1 (rad/s).
spectralShape1	Spectral shape factor of wave system 1 (rad/s).
waveHeadingMeanDeg1	Principle wave direction (from, degrees) of wave system 1. 0° for waves from north, and 90° for waves from east.
dirSpreadExp1	Directional spreading exponent of wave system 1.
hs2	Significant wave height of wave system 2 (m).
freqPeak2	Peak wave frequency of wave system 2 (rad/s).
spectralShape2	Spectral shape factor of wave system 2 (rad/s).
waveHeadingMeanDeg2	Principle wave direction (from, degrees) of wave system 2. 0° for waves from north, and 90° for waves from east.
dirSpreadExp2	Directional spreading exponent of wave system 2.

Record (12g2), Endeco Wave Spectrum File Name

This record is required if dirSpectrumOption in Record (12g) is set to EndecoWaveBuoy.

"EndecoSpectrumFileName", EndecoSpectrumFileName (2 character strings)

"EndecoSpectrumFileName"	Record tag.
EndecoSpectrumFileName	Name of ASCII file with wave spectrum from Endeco 956 or 1156 wave buoy. The file name will typically have the extension ".std".

Record (12h), Input Directional Wave Spectrum File Name

This record is required if dirSpectrumOption in Record (12g) is set to InputDir.

"inputDirSpectrumFileName", inputDirSpectrumFileName (2 character strings)

"inputDirSpectrumFileName"	Record tag.
inputDirSpectrumFileName	Input directional wave spectrum file name. The format of the directional wave spectrum file is given in Annex A.2.

Record (12i), End of Multi-directional Seaway from Input Spectrum

This record is required if seawayOption in Record (7) is set to DirSpectrum.

"end dirSpectrumSeaway" (1 character string with 2 words)

Record (13), Beginning of Seaway from Input Components, Randomly Generated Phases

Records (13) to (13c) are required if seawayOption is set to componentRandom in Record (7).

"begin componentRandomSeaway" (1 character string with 2 words)

Record (13a), Wave Phase Seed Number

This record can be optionally used if seawayOption in Record (7) is set to componentRandom. If this record is omitted, then a default will be used.

"compPhaseSeed", seed (1 character string, 1 integer)

"compPhaseSeed"	Record tag.
phaseSeed	Integer seed number (default 1001).

Record (13b), Wave Component Properties

This record can be repeated to describe a seaway consisting of multiple wave components.

"componentRandom", waveHeadingDeg, waveFreq, waveAmp (1 character string, 3 floats)

"componentRandom"	Record tag.
waveHeadingDeg	Wave direction (from, degrees). 0° for waves from north, and 90° for waves from east.
waveFreq	Incident wave frequency (rad/s).
waveAmp	Incident wave amplitude (m).

Record (13c), End of Seaway from Input Components, Randomly Generated Phases

This record is required if seawayOption is set to ComponentRandom in Record (7).

"end componentRandomSeaway" (1 character string with 2 words)

Record (14), Beginning of Seaway from Input Components Including Phases

Records (14) to (14b) are required if seawayOption is set to ComponentPhase in Record (7).

"begin componentPhaseSeaway" (1 character string with 2 words)

Record (14a), Wave Component Properties

This record can be repeated to describe a seaway consisting of multiple wave components.

"componentPhase", waveHeadingDeg, waveFreq, waveAmp, phaseDeg (1 character string, 4 floats)

"componentPhase"	Record tag.
waveHeadingDeg	Wave direction (from, degrees). 0° for waves from north, and 90° for waves from east.
waveFreq	Incident wave frequency (rad/s).
waveAmp	Incident wave amplitude (m).
phaseDeg	Phase of incident wave crest at $x^f = 0, y^f = 0$ (deg).

Record (14b), End of Seaway from Input Components with Input Phases

This record is required if seawayOption is set to componentPhase in Record (7).

"end componentPhaseSeaway" (1 character string with 2 words)

Record (15), Plot Output Option

This record is optional.

"plotOutOption", plotOutOption (2 character strings)

"plotOutOption"	Record tag.
plotOutOption	Option for making plots:
	NoPlot - No plots are produced.
	Screen - Plots are only plotted on the screen (default).
	ScreenFile - Plots are both plotted on the screen and to a file.
	File - Plots are only written to a file.

Record (16), Beginning of Seaway Plot Data

This record is optional.

"begin plots" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (16a) to (16j) giving plot parameters. Record (16k) must follow at the end of plot parameter data.

Record (16a), Seaway Plot Image File Name

This record is required if a plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (16b), Seaway Plot Image Format

This record is optional if a plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (16c), Seaway Plot Image Size

This record is optional if a plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 100 mm)

Record (16d), Seaway Plot Camera Settings

This record is required if a plot is being specified.

"camera", camPosHorAngleDeg, camPosVertAngleDeg, camViewAngleDeg (1 character string, 3 floats)

"camera"	Record tag.
camPosHorAngleDeg	Horizontal position (deg) of camera relative to seaway (0° for front, 90° for left).
camPosHorAngleDeg	Vertical position (deg) of camera relative to seaway (0° for horizontal, 90° for above).
camViewAngleDeg	Camera view angle (deg).

Record (16e), Seaway Plot Lighting Settings

This record is optional if a plot is being specified.

"lighting", ambientLightIntensity, directLightIntensity, directLightHorAngleDeg, directLightVertAngleDeg (1 character string, 3 floats)

"lighting"	Record tag.
ambientLightIntensity	Ambient light intensity (default 0.5).
directLightIntensity	Direct light intensity (default 1.0).
directLightHorAngleDeg	Horizontal position (deg) of direct light source relative to seaway (0° for front, 90° for left, default 0°).
directLightVertAngleDeg	Vertical position (deg) of direct light source to seaway (0° for horizontal, 90° for above, default 45°).

Record (16f), Seaway Plot Options

This record is required if a plot is being specified.

“plotOptions”, colourTable, smoothShadeOption, showMeshOption (4 character strings)

“plotOptions”	Record tag.
colourTable	Colour table:
	BlueGreenRedScale - Elevation colours ranging from blue to red.
	PartialGreyScale - Elevation colours ranging from grey to white.
	GreyScale - Elevation colours ranging from black to white.
	BlueTurquoiseScale - Elevation colours ranging from blue to turquoise.
	BlueWhiteScale - Elevation colours ranging from blue to white.
	WhiteScale - Solid white
smoothShadeOption	Option for shading of seaway panels:
	Solid - Each panel has a solid colour based on the centroid location.
	Smooth - Each panel can have colour variation within the panel.
showMeshOption	Option for plotting the mesh:
	ShowMesh - The seaway surface mesh is plotted.
	HideMesh - No surface mesh is plotted.

Record (16g), X Plot Range

This record is required if a plot is being specified.

“xfRange”, xfMin, xfMax, xfInc (1 character string, 3 floats)

“xfRange”	Record tag.
xfMin	Minimum x^f coordinate of surface mesh.
xfMax	Maximum x^f coordinate of surface mesh.
xfInc	Increment of x^f coordinate of surface mesh.

Record (16h), Y Plot Range

This record is required if a plot is being specified.

“yfRange”, yfMin, yfMay, yfInc (1 character string, 3 floats)

“yfRange”	Record tag.
yfMin	Minimum y^f coordinate of surface mesh.
yfMay	Maximum y^f coordinate of surface mesh.
yfInc	Increment of y^f coordinate of surface mesh.

Record (16i), Time of plot.

This record is optional if a plot is being specified.

“time”, time (1 character string, 1 floats)

“time”	Record tag.
time	Time at which sea surface is plotted (default 0.0).

Record (16j), Mesh Line Thickness

This record is optional if a plot is being specified.

“lineThickness’, lineThickness (1 character string, 1 float)

“lineThickness”	Record tag.
lineThickness	Line thickness of mesh (default 1.0).

Record (16k), End of Plot Data

“end plots” (1 character string with 2 words)

Record (17), End of Seaway

"end SM3DBuildSeaway3"(1 character string with 2 words)

A.2 Format of Input Directional Spectrum File for SM3DBuildSeaway3

Record (1), Beginning Record

"begin inputDirSpectrum"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for spectrum. This can include spaces.

Record (3), Significant Wave Height and Characteristic Wave Period

"hsTchar", hs, tChar (1 character string, 2 floats)

"hsTchar" Record tag.

hs Significant wave height (m)

tChar Characteristic wave period (s)

Record (4a), Range of Wave Frequencies

One of Records (4a) or (4b) must be given.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc (1 character string, 3 floats)

"waveFreqRange" Record tag.

waveFreqMin Minimum wave frequency (rad/s).

waveFreqMax Maximum wave frequency (rad/s).

waveFreqInc Increment for wave frequency (rad/s).

Record (4b), Wave Frequencies

One of Records (4b) or (4b) must be given.

"waveFreqs", waveFreqs (1 character string, array of floats)

"waveFreqs" Record tag.

waveFreqs Array of increasing incident wave frequencies (rad/s).

Record (5a), Wave Direction Range

One of Records (5a) or (5b) must be given.

"waveDirFromRange", waveDirFromDegMin, waveDirFromDegMax, waveDirFromDegInc (1 character string, 3 floats)

"waveDirFromRange"	Record tag.
waveDirFromDegMin	Minimum wave direction (deg).
waveDirFromDegMax	Maximum wave direction (deg).
waveDirFromDegInc	Wave direction increment (deg).
Note:	Wave directions are given using a convention of 0° for waves from north, 90° for waves from east.

Record (5b), Wave Directions

One of Records (5a) or (5b) must be given.

"waveDirsFrom", waveDirsFromDeg (1 character string, array of floats)

"waveDirsFrom"	Record tag.
waveDirsFromDeg	Wave directions for integration of ship motion spectrum. Wave directions are given using a convention of 0° for waves from north, 90° for waves from east.

Record (6), Wave Energy Spectral Densities for Specified Wave Frequencies.

nWaveFreq Records must be given, where nWaveFreq is the number of wave frequencies specified by Record (4a) or (4b)

"energyDensities", waveFreq, energyDensitiesDirDeg (1 character string, 1 + nWaveDir floats)

"energyDensities"	Record tag.
waveFreq	Wave frequency for energy densities within Record. This value must be consistent with wave frequencies specified by Record (4a) or (4b).
energyDensitiesDirDeg	Energy densities (m2/(rad/s)/deg) for frequency waveFreq and wave directions specified in Record (5a) or (5b).

Record (7), End Record

“end inputDirSpectrum”(1 character string with 2 words)

A.3 Sample Input Directional Spectrum File for SM3DBuildSeaway3

```
begin inputDirSpectrum
label Bretschenider spectrum, Hs = 5.0 m, Tp = 12.4 s, heading = 180 deg, !
                              spreading = 90 deg
hsTchar 5.0 12.4
waveFreqRange 0.2 2.0 0.05
waveDirFromRange 90.0 270.0 5.0
energyDensities     0.200  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000
energyDensities     0.250  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  !
       0.000000  0.000000  0.000000  0.000000
energyDensities     0.300  0.000000  0.000001  0.000003  0.000006  0.000010  !
       0.000016  0.000022  0.000030  0.000037  0.000045  0.000053  0.000060  !
       0.000067  0.000074  0.000079  0.000084  0.000087  0.000089  0.000090  !
       0.000089  0.000087  0.000084  0.000079  0.000074  0.000067  0.000060  !
       0.000053  0.000045  0.000037  0.000030  0.000022  0.000016  0.000010  !
       0.000006  0.000003  0.000001  0.000000
energyDensities     0.350  0.000000  0.000034  0.000135  0.000300  0.000524  !
       0.000801  0.001120  0.001475  0.001852  0.002241  0.002630  0.003007  !
       0.003361  0.003681  0.003958  0.004182  0.004347  0.004448  0.004482  !
       0.004448  0.004347  0.004182  0.003958  0.003681  0.003361  0.003007  !
       0.002630  0.002241  0.001852  0.001475  0.001120  0.000801  0.000524  !
       0.000300  0.000135  0.000034  0.000000
energyDensities     0.400  0.000000  0.000169  0.000673  0.001494  0.002609  !
       0.003984  0.005576  0.007338  0.009216  0.011152  0.013089  0.014967  !
       0.016729  0.018321  0.019696  0.020811  0.021632  0.022135  0.022305  !
       0.022135  0.021632  0.020811  0.019696  0.018321  0.016729  0.014967  !
       0.013089  0.011152  0.009216  0.007338  0.005576  0.003984  0.002609  !
       0.001494  0.000673  0.000169  0.000000
energyDensities     0.450  0.000000  0.000315  0.001251  0.002779  0.004852  !
       0.007409  0.010370  0.013647  0.017139  0.020741  0.024342  0.027834  !
       0.031111  0.034072  0.036629  0.038703  0.040230  0.041166  0.041481  !
       0.041166  0.040230  0.038703  0.036629  0.034072  0.031111  0.027834  !
       0.024342  0.020741  0.017139  0.013647  0.010370  0.007409  0.004852  !
       0.002779  0.001251  0.000315  0.000000
energyDensities     0.500  0.000000  0.000371  0.001474  0.003275  0.005719  !
       0.008732  0.012222  0.016083  0.020199  0.024444  0.028688  0.032804  !
       0.036666  0.040156  0.043169  0.045613  0.047413  0.048516  0.048887  !
       0.048516  0.047413  0.045613  0.043169  0.040156  0.036666  0.032804  !
       0.028688  0.024444  0.020199  0.016083  0.012222  0.008732  0.005719  !
```

```
        0.003275  0.001474  0.000371  0.000000
energyDensities      0.550  0.000000  0.000350  0.001390  0.003088  0.005393  !
        0.008234  0.011526  0.015168  0.019049  0.023052  0.027055  0.030936  !
        0.034578  0.037870  0.040711  0.043016  0.044714  0.045754  0.046104  !
        0.045754  0.044714  0.043016  0.040711  0.037870  0.034578  0.030936  !
        0.027055  0.023052  0.019049  0.015168  0.011526  0.008234  0.005393  !
        0.003088  0.001390  0.000350  0.000000
energyDensities      0.600  0.000000  0.000295  0.001172  0.002605  0.004548  !
        0.006945  0.009721  0.012792  0.016065  0.019441  0.022817  0.026090  !
        0.029162  0.031938  0.034334  0.036278  0.037710  0.038587  0.038882  !
        0.038587  0.037710  0.036278  0.034334  0.031938  0.029162  0.026090  !
        0.022817  0.019441  0.016065  0.012792  0.009721  0.006945  0.004548  !
        0.002605  0.001172  0.000295  0.000000
energyDensities      0.650  0.000000  0.000236  0.000935  0.002078  0.003628  !
        0.005540  0.007754  0.010204  0.012815  0.015508  0.018201  0.020813  !
        0.023263  0.025477  0.027389  0.028939  0.030082  0.030781  0.031017  !
        0.030781  0.030082  0.028939  0.027389  0.025477  0.023263  0.020813  !
        0.018201  0.015508  0.012815  0.010204  0.007754  0.005540  0.003628  !
        0.002078  0.000935  0.000236  0.000000
energyDensities      0.700  0.000000  0.000183  0.000727  0.001615  0.002820  !
        0.004305  0.006026  0.007930  0.009960  0.012052  0.014145  0.016175  !
        0.018079  0.019800  0.021285  0.022490  0.023378  0.023922  0.024105  !
        0.023922  0.023378  0.022490  0.021285  0.019800  0.018079  0.016175  !
        0.014145  0.012052  0.009960  0.007930  0.006026  0.004305  0.002820  !
        0.001615  0.000727  0.000183  0.000000
energyDensities      0.750  0.000000  0.000141  0.000559  0.001242  0.002169  !
        0.003312  0.004636  0.006101  0.007662  0.009273  0.010883  0.012444  !
        0.013909  0.015233  0.016376  0.017303  0.017986  0.018404  0.018545  !
        0.018404  0.017986  0.017303  0.016376  0.015233  0.013909  0.012444  !
        0.010883  0.009273  0.007662  0.006101  0.004636  0.003312  0.002169  !
        0.001242  0.000559  0.000141  0.000000
energyDensities      0.800  0.000000  0.000108  0.000430  0.000955  0.001667  !
        0.002545  0.003563  0.004688  0.005888  0.007125  0.008362  0.009562  !
        0.010688  0.011705  0.012583  0.013296  0.013821  0.014142  0.014250  !
        0.014142  0.013821  0.013296  0.012583  0.011705  0.010688  0.009562  !
        0.008362  0.007125  0.005888  0.004688  0.003563  0.002545  0.001667  !
        0.000955  0.000430  0.000108  0.000000
energyDensities      0.850  0.000000  0.000083  0.000331  0.000736  0.001286  !
        0.001963  0.002747  0.003616  0.004541  0.005495  0.006449  0.007374  !
        0.008242  0.009027  0.009704  0.010254  0.010659  0.010906  0.010990  !
        0.010906  0.010659  0.010254  0.009704  0.009027  0.008242  0.007374  !
        0.006449  0.005495  0.004541  0.003616  0.002747  0.001963  0.001286  !
        0.000736  0.000331  0.000083  0.000000
energyDensities      0.900  0.000000  0.000065  0.000257  0.000571  0.000998  !
        0.001523  0.002132  0.002806  0.003524  0.004264  0.005005  0.005723  !
        0.006397  0.007006  0.007531  0.007957  0.008272  0.008464  0.008529  !
        0.008464  0.008272  0.007957  0.007531  0.007006  0.006397  0.005723  !
        0.005005  0.004264  0.003524  0.002806  0.002132  0.001523  0.000998  !
        0.000571  0.000257  0.000065  0.000000
energyDensities      0.950  0.000000  0.000051  0.000201  0.000447  0.000780  !
        0.001191  0.001667  0.002194  0.002756  0.003335  0.003914  0.004475  !
```

```
         0.005002  0.005478  0.005889  0.006223  0.006468  0.006619  0.006669  !
         0.006619  0.006468  0.006223  0.005889  0.005478  0.005002  0.004475  !
         0.003914  0.003335  0.002756  0.002194  0.001667  0.001191  0.000780  !
         0.000447  0.000201  0.000051  0.000000
energyDensities     1.000  0.000000  0.000040  0.000159  0.000352  0.000615  !
         0.000939  0.001315  0.001730  0.002173  0.002629  0.003086  0.003528  !
         0.003944  0.004319  0.004643  0.004906  0.005100  0.005219  0.005258  !
         0.005219  0.005100  0.004906  0.004643  0.004319  0.003944  0.003528  !
         0.003086  0.002629  0.002173  0.001730  0.001315  0.000939  0.000615  !
         0.000352  0.000159  0.000040  0.000000
energyDensities     1.050  0.000000  0.000032  0.000126  0.000280  0.000489  !
         0.000747  0.001045  0.001375  0.001727  0.002090  0.002453  0.002805  !
         0.003136  0.003434  0.003692  0.003901  0.004055  0.004149  0.004181  !
         0.004149  0.004055  0.003901  0.003692  0.003434  0.003136  0.002805  !
         0.002453  0.002090  0.001727  0.001375  0.001045  0.000747  0.000489  !
         0.000280  0.000126  0.000032  0.000000
energyDensities     1.100  0.000000  0.000025  0.000101  0.000225  0.000392  !
         0.000599  0.000838  0.001103  0.001385  0.001676  0.001967  0.002249  !
         0.002514  0.002753  0.002959  0.003127  0.003250  0.003326  0.003352  !
         0.003326  0.003250  0.003127  0.002959  0.002753  0.002514  0.002249  !
         0.001967  0.001676  0.001385  0.001103  0.000838  0.000599  0.000392  !
         0.000225  0.000101  0.000025  0.000000
energyDensities     1.150  0.000000  0.000021  0.000082  0.000181  0.000317  !
         0.000484  0.000677  0.000891  0.001119  0.001354  0.001589  0.001817  !
         0.002031  0.002225  0.002391  0.002527  0.002627  0.002688  0.002708  !
         0.002688  0.002627  0.002527  0.002391  0.002225  0.002031  0.001817  !
         0.001589  0.001354  0.001119  0.000891  0.000677  0.000484  0.000317  !
         0.000181  0.000082  0.000021  0.000000
energyDensities     1.200  0.000000  0.000017  0.000067  0.000148  0.000258  !
         0.000394  0.000551  0.000726  0.000911  0.001103  0.001294  0.001480  !
         0.001654  0.001811  0.001947  0.002058  0.002139  0.002189  0.002205  !
         0.002189  0.002139  0.002058  0.001947  0.001811  0.001654  0.001480  !
         0.001294  0.001103  0.000911  0.000726  0.000551  0.000394  0.000258  !
         0.000148  0.000067  0.000017  0.000000
energyDensities     1.250  0.000000  0.000014  0.000055  0.000121  0.000212  !
         0.000323  0.000452  0.000595  0.000747  0.000904  0.001062  0.001214  !
         0.001357  0.001486  0.001597  0.001688  0.001754  0.001795  0.001809  !
         0.001795  0.001754  0.001688  0.001597  0.001486  0.001357  0.001214  !
         0.001062  0.000904  0.000747  0.000595  0.000452  0.000323  0.000212  !
         0.000121  0.000055  0.000014  0.000000
energyDensities     1.300  0.000000  0.000011  0.000045  0.000100  0.000175  !
         0.000267  0.000374  0.000492  0.000617  0.000747  0.000877  0.001003  !
         0.001121  0.001227  0.001319  0.001394  0.001449  0.001483  0.001494  !
         0.001483  0.001449  0.001394  0.001319  0.001227  0.001121  0.001003  !
         0.000877  0.000747  0.000617  0.000492  0.000374  0.000267  0.000175  !
         0.000100  0.000045  0.000011  0.000000
energyDensities     1.350  0.000000  0.000009  0.000037  0.000083  0.000145  !
         0.000222  0.000311  0.000409  0.000513  0.000621  0.000729  0.000834  !
         0.000932  0.001020  0.001097  0.001159  0.001205  0.001233  0.001242  !
         0.001233  0.001205  0.001159  0.001097  0.001020  0.000932  0.000834  !
         0.000729  0.000621  0.000513  0.000409  0.000311  0.000222  0.000145  !
```

```
        0.000083  0.000037  0.000009  0.000000
energyDensities      1.400  0.000000  0.000008  0.000031  0.000070  0.000122  !
        0.000186  0.000260  0.000342  0.000429  0.000520  0.000610  0.000697  !
        0.000779  0.000854  0.000918  0.000970  0.001008  0.001031  0.001039  !
        0.001031  0.001008  0.000970  0.000918  0.000854  0.000779  0.000697  !
        0.000610  0.000520  0.000429  0.000342  0.000260  0.000186  0.000122  !
        0.000070  0.000031  0.000008  0.000000
energyDensities      1.450  0.000000  0.000007  0.000026  0.000059  0.000102  !
        0.000156  0.000219  0.000288  0.000361  0.000437  0.000513  0.000587  !
        0.000656  0.000718  0.000772  0.000816  0.000848  0.000868  0.000874  !
        0.000868  0.000848  0.000816  0.000772  0.000718  0.000656  0.000587  !
        0.000513  0.000437  0.000361  0.000288  0.000219  0.000156  0.000102  !
        0.000059  0.000026  0.000007  0.000000
energyDensities      1.500  0.000000  0.000006  0.000022  0.000050  0.000087  !
        0.000132  0.000185  0.000243  0.000306  0.000370  0.000434  0.000496  !
        0.000555  0.000608  0.000653  0.000690  0.000718  0.000734  0.000740  !
        0.000734  0.000718  0.000690  0.000653  0.000608  0.000555  0.000496  !
        0.000434  0.000370  0.000306  0.000243  0.000185  0.000132  0.000087  !
        0.000050  0.000022  0.000006  0.000000
energyDensities      1.550  0.000000  0.000005  0.000019  0.000042  0.000074  !
        0.000112  0.000157  0.000207  0.000260  0.000315  0.000369  0.000422  !
        0.000472  0.000517  0.000556  0.000587  0.000610  0.000624  0.000629  !
        0.000624  0.000610  0.000587  0.000556  0.000517  0.000472  0.000422  !
        0.000369  0.000315  0.000260  0.000207  0.000157  0.000112  0.000074  !
        0.000042  0.000019  0.000005  0.000000
energyDensities      1.600  0.000000  0.000004  0.000016  0.000036  0.000063  !
        0.000096  0.000134  0.000177  0.000222  0.000269  0.000316  0.000361  !
        0.000403  0.000442  0.000475  0.000502  0.000522  0.000534  0.000538  !
        0.000534  0.000522  0.000502  0.000475  0.000442  0.000403  0.000361  !
        0.000316  0.000269  0.000222  0.000177  0.000134  0.000096  0.000063  !
        0.000036  0.000016  0.000004  0.000000
energyDensities      1.650  0.000000  0.000004  0.000014  0.000031  0.000054  !
        0.000082  0.000115  0.000152  0.000191  0.000231  0.000271  0.000310  !
        0.000346  0.000379  0.000408  0.000431  0.000448  0.000458  0.000462  !
        0.000458  0.000448  0.000431  0.000408  0.000379  0.000346  0.000310  !
        0.000271  0.000231  0.000191  0.000152  0.000115  0.000082  0.000054  !
        0.000031  0.000014  0.000004  0.000000
energyDensities      1.700  0.000000  0.000003  0.000012  0.000027  0.000047  !
        0.000071  0.000100  0.000131  0.000165  0.000199  0.000234  0.000267  !
        0.000299  0.000327  0.000352  0.000372  0.000386  0.000395  0.000398  !
        0.000395  0.000386  0.000372  0.000352  0.000327  0.000299  0.000267  !
        0.000234  0.000199  0.000165  0.000131  0.000100  0.000071  0.000047  !
        0.000027  0.000012  0.000003  0.000000
energyDensities      1.750  0.000000  0.000003  0.000010  0.000023  0.000040  !
        0.000062  0.000086  0.000113  0.000142  0.000172  0.000202  0.000231  !
        0.000259  0.000283  0.000305  0.000322  0.000334  0.000342  0.000345  !
        0.000342  0.000334  0.000322  0.000305  0.000283  0.000259  0.000231  !
        0.000202  0.000172  0.000142  0.000113  0.000086  0.000062  0.000040  !
        0.000023  0.000010  0.000003  0.000000
energyDensities      1.800  0.000000  0.000002  0.000009  0.000020  0.000035  !
        0.000054  0.000075  0.000099  0.000124  0.000150  0.000176  0.000201  !
```

```
      0.000225  0.000246  0.000265  0.000280  0.000291  0.000298  0.000300  !
      0.000298  0.000291  0.000280  0.000265  0.000246  0.000225  0.000201  !
      0.000176  0.000150  0.000124  0.000099  0.000075  0.000054  0.000035  !
      0.000020  0.000009  0.000002  0.000000
energyDensities     1.850  0.000000  0.000002  0.000008  0.000018  0.000031  !
      0.000047  0.000065  0.000086  0.000108  0.000131  0.000154  0.000176  !
      0.000196  0.000215  0.000231  0.000244  0.000254  0.000260  0.000262  !
      0.000260  0.000254  0.000244  0.000231  0.000215  0.000196  0.000176  !
      0.000154  0.000131  0.000108  0.000086  0.000065  0.000047  0.000031  !
      0.000018  0.000008  0.000002  0.000000
energyDensities     1.900  0.000000  0.000002  0.000007  0.000015  0.000027  !
      0.000041  0.000057  0.000075  0.000095  0.000115  0.000134  0.000154  !
      0.000172  0.000188  0.000202  0.000214  0.000222  0.000227  0.000229  !
      0.000227  0.000222  0.000214  0.000202  0.000188  0.000172  0.000154  !
      0.000134  0.000115  0.000095  0.000075  0.000057  0.000041  0.000027  !
      0.000015  0.000007  0.000002  0.000000
energyDensities     1.950  0.000000  0.000002  0.000006  0.000013  0.000024  !
      0.000036  0.000050  0.000066  0.000083  0.000101  0.000118  0.000135  !
      0.000151  0.000165  0.000178  0.000188  0.000195  0.000200  0.000201  !
      0.000200  0.000195  0.000188  0.000178  0.000165  0.000151  0.000135  !
      0.000118  0.000101  0.000083  0.000066  0.000050  0.000036  0.000024  !
      0.000013  0.000006  0.000002  0.000000
energyDensities     2.000  0.000000  0.000001  0.000005  0.000012  0.000021  !
      0.000032  0.000044  0.000058  0.000073  0.000089  0.000104  0.000119  !
      0.000133  0.000146  0.000157  0.000166  0.000172  0.000176  0.000178  !
      0.000176  0.000172  0.000166  0.000157  0.000146  0.000133  0.000119  !
      0.000104  0.000089  0.000073  0.000058  0.000044  0.000032  0.000021  !
      0.000012  0.000005  0.000001  0.000000
end inputDirSpectrum
```

A.4 Sample Input File for SM3DBuildSeaway3

```
begin SM3DBuildSeaway3
label Hs = 3.25 m, Tp = 9.7 s, Bretschneider spectrum
seawayFileName bretSeaState5Seaway.xml
waterDensity 1025
sampleParams 3600 0.1
seawayOption UniSpectrum
begin uniSpectrumSeaway
    waveFreqRange 0.2 2 0.05 randomInc 2001
    phaseSeed 1001
    deleteRelThreshEnergy 1E-06
    waveHeading 0
    uniSpectrumOption Bretschneider
    BretParam 3.25 9.7
end uniSpectrumSeaway
end SM3DBuildSeaway3
```

A.5 Sample Output File for SM3DBuildSeaway3

```
Program SM3DBuildSeaway
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-09-11 8:20:46 AM
Run label:
Hs = 3.25 m, Tp = 9.7 s, Bretschneider spectrum

**** ECHO OF USER INPUT ****

Wave heading convention is 0 deg for waves from north, 90 deg from east
Phase convention is lead of crest at origin xf=0, yf=0

Output seaway file name:
bretSeaState5Seaway.xml

Water density :  1025.000 kg/m3

Parameters for sampling of seaway statistics (input)
Duration : 3600.000 s
Interval : 0.100 s

Seaway type : UniSpectrum

Seaway from uni-directional wave spectrum
Minimum wave frequency   :        0.200 rad/s
Maximum wave frequency   :        2.000 rad/s
Wave frequency increment :        0.050 rad/s
Option for random adjustment of wave frequency increment: RandomInc
Seed number for random adjustment of wave freq increment: 2001
Wave component phase seed numbers: 1001 (input)
User input threshold for relative energy : 1E-06
Wave heading                   0.000 deg (from)
Unidirectional spectrum option : Bretschneider
Parameters for unidirectional Bretschneider spectrum
Significant wave height        3.250 m
Peak wave period               9.700 s

Plot output option : File

**** PROPERTIES OF MULTI-COMPONENT SEAWAY ****

Multi-component seaway in earth-fixed axes
Significant wave height assuming random phases :      3.234 m
```

Wave component properties

Heading (deg)	Frequency (rad/s)	Amplitude (m)	Phase (deg)
0.000	0.349345	0.002402	198.511
0.000	0.418409	0.055160	70.582
0.000	0.437714	0.094406	81.966
0.000	0.517538	0.291281	154.988
0.000	0.554448	0.306792	158.412
0.000	0.604834	0.386297	8.321
0.000	0.662306	0.365597	156.378
0.000	0.697024	0.316578	70.481
0.000	0.734546	0.375214	297.382
0.000	0.807591	0.342888	127.010
0.000	0.851395	0.264564	88.077
0.000	0.889681	0.241294	80.367
0.000	0.930918	0.254865	227.058
0.000	0.994664	0.230586	220.868
0.000	1.042700	0.188533	197.976
0.000	1.085678	0.181435	208.965
0.000	1.143028	0.163821	258.803
0.000	1.188408	0.163712	307.284
0.000	1.265374	0.144852	183.054
0.000	1.316318	0.099871	14.807
0.000	1.338522	0.106165	59.607
0.000	1.405762	0.112056	175.743
0.000	1.464295	0.082318	312.384
0.000	1.488291	0.085054	331.497
0.000	1.559574	0.081297	209.033
0.000	1.597439	0.072998	39.277
0.000	1.658453	0.073645	323.848
0.000	1.718254	0.058012	147.980
0.000	1.747604	0.055811	333.016
0.000	1.807912	0.057250	169.246
0.000	1.859051	0.048903	354.382
0.000	1.901196	0.043427	45.827
0.000	1.941211	0.045237	197.320
0.000	2.000000	0.032415	353.648

```
**** Wave elevation time series statistics ****
Mean                    :     -0.001 m
Standard deviation      :      0.807 m
Minimum                 :     -3.010 m
Maximum                 :      2.632 m
Zero-crossing period    :     7.364 s
```

```
Significant wave height based on RMS wave elevation :     3.234 m

Computation time : 0 s
```

Annex B: Files for Simulating Motions of Freely Maneuvering Ship with SM3DFreeMo3

B.1 Format of Input File for Simulating Motion of a Freely Maneuvering Ship with SM3DFreeMo3

Record (1), Beginning Record

"begin SM3DFreeMo3"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText (character string)

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"end note" (1 character string with 2 words)

Record (4), Input Ship Database File Name

“shipDBFileName”, (2 character strings)

“shipDBFileName”	Record tag.
shipDBFileName	Name of input ship database file in .NET binary serialization format. This file must have been created using program SM3DBuildShip3.

Record (5), Length Data

“lengthData”, lpp, stationAP (1 character string, 2 floats)

“lengthData”	Record tag.
lpp	Ship length between perpendiculars (m)
stationAP	Station number of the aft perpendicular. This value is typically 20.0
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 m for length, and 0.001 for the station of the aft perpendicular. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (6), Ship Loading Condition

"loadCondition", waterDensity, draftBlMid, trimBlStern, shipKG, correctionGM (1 character string, 5 floats)

"loadCondition"	Record tag.
waterDensity	Water density (kg/m^3).
draftBlMid	Draft of baseline at midships (m).
trimBlStern	Trim of baseline by stern (m).
shipKG	Height of centre of gravity above baseline (m).
correctionGM	Correction to metacentric height (m).
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 kg/m^3 for density, and 0.001 m for draft, trim, height of CG, and metacentric height. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (7), Beginning of Rudder Autopilot Settings

"begin rudderAutopilotSettings" (2 character strings)

Records (7) to (7g) are optional.

"begin rudderAutopilotSettings"	Record tag.
Note:	Records (7) to (7g) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (7) to (7g), Records (7a) to (7f) can be repeated an arbitrary number of times to set rudder autopilot parameters as required.

Record (7a), Rudder Key for Autopilot Settings

“keyRudder” keyRudder (2 character strings)

This Record must follow Record (7) if autopilot settings are being given as input.

“keyRudder”	Record tag.
keyRudder	Key of rudder for which autopilot settings are being specified. If the rudder key is set to “All”, then the input autopilot settings are applied to all rudders.

Record (7b), Rudder Autopilot Control Parameters

This record can optionally be entered if an autopilot key has been specified using Record (7a)

“controlParam”, deflectMaxDeg, velMaxDeg, accMaxDeg, freqResponse, dampResponse, dtMax (1 character string, 6 floats)

“controlParam”	Record tag.
deflectMaxDeg	Maximum rudder deflection angle (deg). This value is typically set to 35°.
velMaxDeg	Maximum rudder deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
accMaxDeg	Maximum rudder acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
freqResponse	Undamped response frequency of rudder autopilot.
dampResponse	Damping of rudder autopilot as a fraction of critical damping. This value is typically between 0.5 and 1.0
dtMax	Maximum time increment for time stepping of rudder motions. If this value is set to 0.0, then no limit is applied and time stepping is done using the same time increment as for ship motions.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7c), Rudder Autopilot Displacement Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a)

"dispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"dispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless rudder roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7d), Rudder Velocity Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"velGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"velGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless rudder stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7e), Rudder Integral Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a)

"intGains", surgeIntGain, swayIntGain, heaveIntGain, rollIntGain, pitchIntGain, yawIntGain (1 character string, 6 floats)

"intGains"	Record tag.
surgeIntGain	Surge integral gain (deg/(m·s)). This value should be 0.0.
swayIntGain	Sway integral gain (deg/(m·s)). This value should be 0.0.
heaveIntGain	Heave integral gain (deg/(m·s)). This value is typically 0.0.
rollIntGain	Roll integral gain (deg/(deg·s)). This value is typically 0.0 unless rudder stabilization is desired.
pitchIntGain	Pitch integral gain (deg/(deg·s)). This value is typically 0.0.
yawIntGain	Yaw integral gain (deg/(deg·s)). For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7f), Rudder Autopilot Integration Time

This record can optionally be entered if an autopilot key has been specified using Record (7a)

"integrationTime", integrationTime (1 character string, 1 float)

"integrationTime"	Record tag.
integrationTime	Integration time for rudder autopilot (s).
Note:	If this record is not included after Record (7a), then the original value for the given ship rudder autopilot is used.

Record (7g), End of Rudder Autopilot Settings

This record is required if Record (7) has been included.

"end rudderAutopilotSettings" (2 character strings)

"end rudderAutopilotSettings"   Record tag.

Record (8), Beginning of Azimuthing Propeller Deflection Controller Settings

"begin aziPropellerDeflectControllerSettings" (2 character strings)

Records (8) to (8g) are optional.

"begin aziPropellerDeflectControllerSettings"	Record tag.
Note:	Records (8) to (8g) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (8) to (8g), Records (8a) to (8f) can be repeated an arbitrary number of times to set azimuthing propeller controller parameters as required.

Record (8a), Azimuthing Propeller Key for Controller Settings

This record must follow Record (8) if controller settings are being given as input.

"keyAziPropeller" keyAziPropeller (1 character string, 1 integer)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller for which controller settings are being specified. If this key to set to "All", then the input controller settings are applied to all azimuthing propeller.

Record (8b), Azimuthing Propeller Deflection Response Parameters

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (8a).

"deflectControlParam", deflectMaxDeg, deflectVelMaxDeg, deflectAccMaxDeg, deflectFreqResponse, deflectDampResponse, dtMax (1 character string, 6 floats)

"deflectControlParam"	Record tag.
deflectMaxDeg	Maximum deflection angle (deg). This value is typically set to 35°.
deflectVelMaxDeg	Maximum deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
deflectAccMaxDeg	Maximum deflection acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
deflectFreqResponse	Undamped response frequency of deflection controller.
deflectDampResponse	Damping of deflection controller as a fraction of critical damping. This value is typically between 0.5 and 1.0.
deflectDtMax	Maximum time increment for time stepping of azimuthing propeller deflections. If this value is set to 0.0, then no limit is applied and time stepping is done using the same time increment as for ship motions.
Note:	If this record is not included after Record (8a), then the original values for the given azimuthing propeller controller are used.

Record (8c), Azimuthing Propeller Deflection Controller Displacement Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (8a).

"deflectDispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"deflectDispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). For a ship with using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (8a), then the original values for the given azimuthing propeller controller are used.

Record (8d), Azimuthing Propeller Deflection Controller Velocity Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (8a).

"deflectVelGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"deflectVelGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). For a ship with using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (8a), then the original values for the given azimuthing propeller controller are used.

Record (8e), Azimuthing Propeller Deflection Controller Integral Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (8a).

"deflectIntGains", surgeIntGain, swayIntGain, heaveIntGain, rollIntGain, pitchIntGain, yawIntGain (1 character string, 6 floats)

"deflectIntGains"	Record tag.
surgeIntGain	Surge integral gain (deg/(m·s)). This value should be 0.0.
swayIntGain	Sway integral gain (deg/(m·s)). This value should be 0.0.
heaveIntGain	Heave integral gain (deg/(m·s)). This value is typically 0.0.
rollIntGain	Roll integral gain (deg/(deg·s)). This value is typically 0.0 unless rudder stabilization is desired.
pitchIntGain	Pitch integral gain (deg/(deg·s)). This value is typically 0.0.
yawIntGain	Yaw integral gain (deg/(deg·s)). For a ship with using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (8a), then the original values for the given azimuthing propeller controller are used.

Record (8f), Azimuthing Propeller Deflection Controller Integration Time

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (8a).

"deflectIntegrationTime", deflectIntegrationTime (1 character string, 1 float)

"deflectIntegrationTime"	Record tag.
deflectIntegrationTime	Integration time for deflection controller (s).
Note:	If this record is not included after Record (8a), then the original values for the given azimuthing propeller controller are used.

Record (8g), End of Azimuthing Propeller Controller Settings

This record is required if Record (8) has been included

"end aziPropellerDeflectControllerSettings" (2 character strings)

Record (9), Output Motion Time Series File Name

"timeSeriesFileName", timeSeriesFileName (2 character strings)

"timeSeriesFileName"	Record tag.
timeSeriesFileName	Name of output ship motion time series in .NET binary serialization format.

Record (10), Seaway Calm Option

"seawayCalmOption", seawayCalmOption (2 character strings)

"seawayCalmOption"	Record tag.
seawayCalmOption	Option for seaway or calm water. Seaway - The simulation includes a seaway with waves. Calm - The simulation is in calm water.

Record (11), Input Seaway File Name

This record should only be given if seawayOption in Record (10) is set to Seaway.

"seawayFileName", seawayFileName (2 character strings)

"seawayFileName"	Record tag.
seawayFileName	Name of input seaway file in .NET XML serialization format. This file must have been created using program SM3DBuildSeaway3.

Record (12), Time Parameters

"timeParameters", dtMax, t0, tEndRampWave, tBeginStats (1 character string, 4 floats)

"timeParameters"	Record tag.
dtMax	Time step for motion computations (s). A suitable time step value depends mainly on the size of the ship, and to a lesser extent on the encountered conditions. A value of 0.2 s has been shown to give reliable results for a naval frigate.
t0	Start time of simulation.
tEndRampWave	End time for reducing wave excitation forces (s). If tEndRampWave is greater than t0, then a ramp function increasing from 0.0 at t0 to 1.0 at tEndRampWave will be applied to wave excitation forces. This feature can be used to reduce transients at the beginning of a simulation.
tBeginStats	Beginning time for sampling motion statistics (s).

Record (13), Nonlinear Option for Buoyancy and Incident (Froude-Krylov) Wave Forces

"hullForceNonLinearOption", hullForceNonLinearOption (2 character strings)

"hullForceNonLinearOption"	Record tag.
hullForceNonLinearOption	Option for using nonlinear computations of forces due to incident waves and buoyancy. BuoyIncident - Nonlinear computation of forces due to incident waves and buoyancy. If this option is used, then the ship file produced by SM3DBuildShip3 and specified in Record (4) must include a dry panelled hull. Linear - Linear computation of forces due to incident waves and buoyancy.

Record (14), Initial Ship Position

"dispsFixed0MDeg", dispsFixed0MDeg (1 character string, 6 floats)

"dispsFixed0MDeg"	Record tag.
dispsFixed0MDeg	Initial ship position in earth-fixed coordinates:
	x^f of ship CG (m, + north).
	y^f of ship CG (m, + west).
	Heave η_3 of ship CG relative to calm water position (m, + up).
	Roll η_4 (deg, + port up).
	Pitch η_5 (deg, + bow down).
	Ship heading χ (deg, 0° for north, 90° for east).

Record (15a), Initial Ship Speed

The input file must include one of Records (15a), (15b), or (15c).

"speed0", speed0 (1 character string, 1 float)

"speed0"	Record tag.
speed0	Initial ship speed along the heading given in Record (14) (m/s).

Record (15b), Initial Ship Speed in Knots

The input file must include one of Records (15a), (15b), or (15c).

"speed0Knots", speed0Knots (1 character string, 1 float)

"speed0Knots"	Record tag.
speed0Knots	Initial ship speed along the heading given in Record (14) (knots).

Record (15c), Initial Ship Velocity for Six Degrees of Freedom

The input file must include one of Records (15a), (15b), or (15c).

"velsFixed0MDeg", velsFixed0MDeg (1 character string, 6 floats)

"velsFixed0MDeg"	Record tag.
velsFixed0MDeg	Initial ship velocity in earth-fixed coordinates:
	$\dot{x}^f$ of ship CG (m/s, + north).
	$\dot{y}^f$ of ship CG (m/s, + west).
	Heave velocity η_3 of ship CG (m/s, + up).
	Roll velocity η_4 (deg/s, + port up).
	Pitch velocity η_5 (deg/s, + bow down).
	Ship heading velocity $\dot{\chi}$ (deg/s, + clockwise viewed from above).

Record (16), Initial Rudder Deflections

This record is optional.

"rudderDeflects0Deg", rudderDeflects0Deg (1 character string, nRudder floats)

"rudderDeflects0Deg"	Record tag.
rudderDeflects0Deg	Initial rudder deflections (deg, + counter-clockwise viewed from inside hull). If this record is not given, then defaults of 0° are used. If this record is given, then the number of values should correspond with the number of rudders in the ship file specified by Record (4).

Record (17), Initial Rudder Velocities

This record is optional.

"rudderVels0Deg", rudderVels0Deg (1 character string, nRudder floats)

"rudderVels0Deg"	Record tag.
rudderVels0Deg	Initial rudder velocities (deg/s, + counter-clockwise viewed from inside hull). If this record is not given, then defaults of 0 deg/s are used. If this record is given, then the number of values should correspond with the number of rudders in the ship file specified by Record (4).

Record (18), Initial Propeller RPMs

This record is optional.

“rpmsPropellers0”, rpmsPropellers0 (1 character string, nPropeller floats)

“rpmsPropellers0”	Record tag.
rpmsPropellers0	Initial propeller RPM values. If this record is not given, then defaults of 0 RPM are used. If this record is given, then the number of values should correspond with the number of propellers in the ship file specified by Record (4).

Record (19), Initial Azimuthing Propeller Deflections

This record is optional.

“aziPropellerDeflects0Deg”, aziPropellerDeflects0Deg (1 character string, nAziPropeller floats)

“aziPropellerDeflects0Deg”	Record tag.
aziPropellerDeflects0Deg	Initial azimuthing propeller deflections (deg, + counter-clockwise viewed from inside hull). If this record is not given, then defaults of 0° are used. If this record is given, then the number of values should correspond with the number of azimuthing propellers in the ship file specified by Record (4).

Record (20), Initial Azimuthing Propeller Deflection Velocities

This record is optional.

“aziPropellerDeflectVels0Deg”, aziPropellerDeflectVels0Deg (1 character string, nAziPropeller floats)

“aziPropellerDeflectVels0Deg”	Record tag.
aziPropellerDeflectVels0Deg	Initial azimuthing propeller velocities (deg/s, + counter-clockwise viewed from inside hull). If this record is not given, then defaults of 0 deg/s are used. If this record is given, then the number of values should correspond with the number of azimuthing propellers in the ship file specified by Record (4).

Record (21), Initial Azimuthing Propeller RPMs

This record is optional.

"aziPropellerRpms0", aziPropellerRpms0 (1 character string, nAziPropeller floats)

"aziPropellerRpms0"	Record tag.
aziPropellerRpms0	Initial azimuthing propeller RPM values. If this record is not given, then defaults of 0 RPM are used. If this record is given, then the number of values should correspond with the number of azimuthing propellers in the ship file specified by Record (4).

Record (22), Initial U-tube Tank Fluid Displacements

This record is optional.

"uTubeTankFluidDisps0Deg", uTubeTankFluidDisps0Deg (1 character string, nUTubeTank floats)

"uTubeTankFluidDisps0Deg"	Record tag.
uTubeTankFluidDisps0Deg	Initial U-tube tank fluid displacement angles (deg, + fluid higher on port side). If this record is not given, then defaults of 0° are used. If this record is given, then the number of values should correspond with the number of U-tube tanks in the ship file specified by Record (4).

Record (23), Initial U-tube Tank Fluid Velocities

This record is optional.

"uTubeTankFluidVels0Deg", uTubeTankFluidVels0Deg (1 character string, nUTubeTank floats)

"uTubeTankFluidVels0Deg"	Record tag.
uTubeTankFluidVels0Deg	Initial fluid angle velocities (deg/s, + fluid moving toward port side). If this record is not given, then defaults of 0 deg/s are used. If this record is given, then the number of values should correspond with the number of U-tube tanks in the ship file specified by Record (4).

Record (24), Beginning of Maneuvers

This record can be followed by Records (24a) to (24j) repeated in arbitrary order.

"begin maneuvers"(1 character string with 2 words)

Record (24a), Propeller RPM Command

This record is optional.

"SetRpm", keyPropeller, rpmCommand (2 character strings, 1 float)

"SetRpm"	Record tag.
keyPropeller	Key for propeller. A value "All" sets all propellers.
rpmCommand	Command propeller RPM (RPM).

Record (24b), Course Command for Rudder

This record is optional.

"SetRudderCourse", keyRudder, shipHeadingToCommandDeg (2 character strings, 1 float)

"SetRudderCourse"	Record tag.
keyRudder	Key for rudder. A value "All" sets all rudders.
shipHeadingToCommandDeg	Ship heading χ (deg) to which autopilot is set.

Record (24c), Rudder Deflection Command

This record is optional.

"SetRudderDeflect", keyRudder, deflectCommandDeg (2 character strings, 1 float)

"SetRudderDeflect"	Record tag.
keyRudder	Key for rudder. A value "All" sets all rudders.
deflectCommandDeg	Command rudder deflection angle (deg, + counter-clockwise viewed from inside the hull). For a ship with a conventional rudder pointing downward, a positive rudder deflection turns the ship to starboard.

Record (24d), Azimuthing Propeller RPM Command

This record is optional.

"SetAziPropellerRpm", keyAziPropeller, rpmCommand (2 character strings, 1 float)

"SetAziPropellerRpm"	Record tag.
keyAziPropeller	Key for azimuthing propeller. A value "All" sets all azimuthing propellers.
rpmCommand	Command RPM for azimuthing propeller (RPM).

Record (24e), Course Command for Azimuthing Propeller

This record is optional.

"SetAziPropellerCourse", keyAziPropeller, shipHeadingToCommandDeg (2 character strings, 1 float)

"SetAziPropellerCourse"	Record tag.
keyAziPropeller	Key for azimuthing propeller. A value "All" sets all azimuthing propellers.
shipHeadingToCommandDeg	Ship heading χ (deg) to which azimuthing propeller autopilot is set.

Record (24f), Azimuthing Propeller Deflection Command

This record is optional.

"SetAziProplerDeflect", keyAziPropeller, deflectCommandDeg (2 character strings, 1 float)

"SetAziProplerDeflect"	Record tag.
keyAziPropeller	Key for azimuthing propeller. A value "All" sets all azimuthing propellers.
deflectCommandDeg	Command azimuthing propeller deflection angle (deg, + counter-clockwise viewed from inside the hull). For a ship with a conventional azimuthing propeller pointing downward, a positive azimuthing propeller deflection turns the ship to starboard.

Record (24g), Turn to Absolute Heading Maneuver Command

This record is optional.

"TurnAbsHeading", finalHeadingDeg, tElapsedMax (optional) (1 character string, 1 or 2 floats)

"TurnAbsHeading"	Record tag.
finalHeadingDeg	Ship heading χ (deg, 0 for north) at which the program considers the command completed. To ensure completion of a turn, a SetRudder command should normally be made before a TurnAbsHeading command.
tElapsedMax	Time limit (s) for attempting to reach heading FinalHeadingDeg. If this input is not included, then a default value of 3600 s is used.

Record (24h), Turn Change in Heading Maneuver Command

This record is optional.

"TurnDeltaHeading", deltaHeadingDeg, tElapsedMax (optional) (1 character string, 1 or 2 floats)

"TurnDeltaHeading"	Record tag.
deltaHeadingDeg	Change from initial heading at which the program considers the turn maneuver completed. To ensure completion of a turn, a SetRudder or SetAziPropllerDeflect command should normally be made before a TurnDeltaHeading command.
tElapsedMax	Time limit (s) for attempting to reach change in heading deltaHeadingDeg. If this input is not included, then a default value of 3600 s is used.

Record (24i), Straight Distance Maneuver Command

This record is optional.

"StraightDistance", distance, tElapsedMax (optional) (1 character string, 1 or 2 floats)

"StraightDistance"	Record tag.
distance	Straight line distance (m) between start and end points at which the program considers the maneuver completed.
tElapsedMax	Time limit (s) for attempting to traverse distance straightDistance. If this input is not included, then a default value of 3600 s is used.

Record (24j), Elapsed Time Maneuver Command

This record is optional.

"ElapsedTime", tElapsedMax (1 character string, 1 float)

"ElapsedTime"	Record tag.
tElapsedMax	Elapsed time at which the program considers the maneuver completed.

Record (24k), End of Maneuvers

This record is required after all maneuvers described using Records (24a) to (24j).

"end maneuvers"(1 character string with 2 words)

Record (25), Time Intervals for Output Time Series and Console

"outTimeIntervals", dtOutTimeSeries, dtOutConsole (1 character string, 1 float)

"outTimeIntervals"	Record tag.
dtOutTimeSeries	Time interval for output time series written to file (s). If this value is set to $\leq$ dtMax from Record (12), then output values will be at an interval of dtMax.
dtOutConsole	Time interval for written simulation progress to console. If this value is set to $\leq$ dtMax from Record (12), then output values will be at an interval of dtMax.

Record (26), Output Ship Motion Time Interval and Options

"outTimeSeries", outDispOption, outVelOption, outAccOption (4 character strings)

"outTimeSeries"	Record tag.
outDispOption	Option for giving output ship displacements:
	Disp - Output displacements are given.
	NoDisp - No output displacements are given.
outVelOption	Option for giving output ship velocities:
	Vel - Output velocities are given.
	NoVel - No output velocities are given.
outAccOption	Option for giving output ship accelerations:
	Acc - Output accelerations are given.
	NoAcc - No output accelerations are given.

Record (27), Output Time Series Options for Rudders, Propellers, Azimuthing Propellers, and U-Tube Tanks

"outAppendage", outRudderOption, outPropOption, outAziPropOption, outUTubeTankOption (5 character strings)

"outAppendage"	Record tag.
outRudderProp	Option for giving output rudder motions:
	Rudder - Output rudder times series are given.
	NoRudder - No rudder time series are given.
outPropOption	Option for giving output propeller RPMs:
	Prop - Output propeller RPM times series are given.
	NoProp - No propeller RPM time series are given.
outAziPropOption	Option for giving output azimuthing propeller deflections RPMs:
	AziProp - Output azimuthing propeller deflection and RPM times series are given.
	NoAziProp - No azimuthing propeller time series are given.
outUTubeTankOption	Option for giving output U-tube tank fluid motions:
	UTubeTank - Output U-tube tank times series are given.
	NoUTubeTank - No U-tube tank time series are given.

Record (28), Plot Option

"plotOutOption", plotOutOption (2 character strings)

"plotOutOption"	Record tag.
plotOutOption	Option for making plots of trajectories and time series.
	NoPlots - No plots are produced.
	ScreenFile - Plots are both plotted on the screen and to a file.
	Screen - Plots are only plotted on the screen.
	File - Plots are only written to a file.

Record (29), Beginning of Trajectory Plot Data

This record is optional.

"begin trajectoryPlot" (1 character string with 2 words)

Note: If this record is entered, then it must be followed by Records (29a) to (29e) giving plot parameters.

Record (29a), Trajectory Plot Image File Name

This record is required if a trajectory plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (29b), Trajectory Plot Image Format

This record is optional if a trajectory plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (29c), Trajectory Plot Image Size

This record is optional if a trajectory plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 100 mm)

Record (29d), Trajectory Plot Drawing of Ship

This record is optional if a trajectory plot is being specified.

"shipDrawing", shipSpacingND, lengthBeamRatio (1 character string, 2 floats)

"shipDrawing"	Record tag.
shipSpacingND	Non-dimensional spacing of drawings of ship on plot (default 5.0).
lengthBeamRatio	Length to beam ratio of drawn ship (default 8.0).
Note:	If this record is omitted for a plot, then the default values are used.

Record (29e), End of Trajectory Plot Data

"end trajectoryPlot" (1 character string with 2 words)

Record (30), Beginning of Displacement Time Series Plot Data

This record is optional.

"begin displacementPlots" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (30a) to (30e) giving plot parameters. Record (30f) must follow at the end of plot parameter data.

Record (30a), Displacement Plot Image File Name

This record is required if a displacement plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (30b), Displacement Plot Image Format

This record is optional if a displacement plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (30c), Displacement Plot Image Size

This record is optional if a displacement plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 100 mm)

Record (30d), Column Options for Motion Displacements

This record is optional if a plot is being specified

"motionColumns", xfColumn, yfColumn, heaveColumn, rollColumn, pitchColumn, headingColumn (7 character strings)

"motionColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
xfColumn	Column of x_f graph (default Left).
yfColumn	Column of y_f graph (default Left).
heaveColumn	Column of heave graph (default Left).
rollColumn	Column of roll graph (default Left).
pitchColumn	Column of pitch graph (default Left).
headingColumn	Column of heading graph (default Left).

Record (30e), Column Options for Rudder and Propeller Displacements

This record is optional if a plot is being specified.

"rudderPropColumns", rudderDeflectColumn, propellerRpmColumn, aziPropellerDeflectColumn, aziPropellerRpmColumn (5 character strings)

"rudderPropColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
rudderDeflectColumn	Column of rudder deflection graph (default Hide).
propellerRpmColumn	Column of propeller RPM graph (default Hide).
aziPropellerDeflectColumn	Column of azimuthing propeller deflection graph (default Hide).
aziPropellerRpmColumn	Column of azimuthing propeller RPM graph (default Hide).

Record (30f), End of Displacement Time Series Plot Data

"end displacementPlots" (1 character string with 2 words)

Record (31), Beginning of Velocity Time Series Plot Data

This record is optional.

"begin velocityPlots" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (31a) to (31e) giving plot parameters. Record (31f) must follow at the end of plot parameter data.

Record (31a), Velocity Plot Image File Name

This record is required if a velocity plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (31b), Velocity Plot Image Format

This record is optional if a velocity plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (31c), Velocity Plot Image Size

This record is optional if a velocity plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 100 mm)

Record (31d), Column Options for Motion Velocities

This record is optional if a velocity plot is being specified.

“motionColumns”, speedColumn, latVelColumn, xfColumn, yfColumn, heaveColumn, rollColumn, pitchColumn, headingColumn (9 character strings)

“motionColumns”	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
speedColumn	Column of speed graph (default Left).
latVelColumn	Column of lateral velocity graph (default Left).
xfColumn	Column of x_f velocity graph (default Hide).
yfColumn	Column of y_f velocity graph (default Hide).
heaveColumn	Column of heave velocity graph (default Left).
rollColumn	Column of roll velocity graph (default Left).
pitchColumn	Column of pitch velocity graph (default Left).
headingColumn	Column of heading velocity graph (default Left).

Record (31e), Column Options for Rudder and Propeller Velocities

This record is optional if a plot is being specified.

“rudderPropColumns”, rudderDeflectColumn, propellerRpmColumn, aziPropellerDeflectColumn, aziPropellerRpmColumn (5 character strings)

“rudderPropColumns”	Record tag. Values for each of the following can be one of: Left Right Hide
rudderDeflectColumn	Column of rudder deflection velocity graph (default Hide).
propellerRpmColumn	Column of propeller RPM rate of change graph (default Hide).
aziPropellerDeflectColumn	Column of azimuthing propeller deflection velocity graph (default Hide).
aziPropellerRpmColumn	Column of azimuthing propeller RPM rate of change graph (default Hide).

Record (31f), End of Velocity Time Series Plot Data

“end velocityPlots” (1 character string with 2 words)

Record (32), Beginning of Acceleration Time Series Plot Data

This record is optional.

“begin accelerationPlots” (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (32a) to (32e) giving plot parameters. Record (32f) must follow at the end of plot parameter data.

Record (32a), Acceleration Plot Image File Name

This record is required if an acceleration plot is being specified.

“imageFileName”, imageFileName (2 character strings)

“imageFileName”	Record tag.
imageFileName	Name of output plot file.

Record (32b), Acceleration Plot Image Format

This record is optional if an acceleration plot is being specified.

“imageFormat”, imageFormat (2 character strings)

“imageFormat”	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (32c), Acceleration Plot Image Size

This record is optional if an acceleration plot is being specified.

“imageSize”, widthmm, heightmm (1 character string, 2 floats)

“imageSize”	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 100 mm)

Record (32d), Column Options for Motion Accelerations

This record is optional if an acceleration plot is being specified

"motionColumns", longAccColumn, latAccColumn, xfColumn, yfColumn, heaveColumn, rollColumn, pitchColumn, headingColumn (9 character strings)

"motionColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
longAccColumn	Column of longitudinal acceleration graph (default Left).
latAccColumn	Column of lateral acceleration graph (default Left).
xfColumn	Column of x_f acceleration graph (default Hide).
yfColumn	Column of y_f acceleration graph (default Hide).
heaveColumn	Column of heave acceleration graph (default Left).
rollColumn	Column of roll acceleration graph (default Left).
pitchColumn	Column of pitch acceleration graph (default Left).
headingColumn	Column of heading acceleration graph (default Left).

Record (32e), Column Options for Rudder and Propeller Accelerations

This record is optional if an acceleration plot is being specified.

“rudderPropColumns”, rudderDeflectColumn, propellerRpmColumn, aziPropellerDeflectColumn, aziPropellerRpmColumn (5 character strings)

“rudderPropColumns”	Record tag. Values for each of the following can be one of: Left Right Hide
rudderDeflectColumn	Column of rudder deflection acceleration graph (default Hide).
propellerRpmColumn	Column of propeller RPM acceleration graph (default Hide).
aziPropellerDeflectColumn	Column of azimuthing propeller deflection acceleration graph (default Hide).
aziPropellerRpmColumn	Column of azimuthing propeller RPM acceleration graph (default Hide).

Record (32f), End of Acceleration Time Series Plot Data

“end accelerationPlots” (1 character string with 2 words)

Record (33), Beginning of Appendage Time Series Plot Data

This record is optional.

“begin appendagePlots” (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (33a) to (33f) giving plot parameters. Record (33i) must follow at the end of plot parameter data.

Record (33a), Appendage Plot Image File Name

This record is required if a plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (33b), Appendage Plot Image Format

This record is optional if a plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (33c), Appendage Plot Image Size

This record is optional if a plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 100 mm)

Record (33d), Column Options for Rudder Deflections

This record is optional if a plot is being specified.

"rudderDeflectColumns", rudderDeflectColumn, rudderDeflectVelColumn, rudderDeflectAccColumn (4 character strings)

"rudderColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
rudderDeflectColumn	Column of rudder deflection graph (default Left).
rudderDeflectVelColumn	Column of rudder deflection velocity graph (default Left).
rudderDeflectAccColumn	Column of rudder deflection velocity graph (default Hide).

Record (33e), Column Options for Propeller RPMs

This record is optional if a plot is being specified.

"propellerRpmColumns", propellerRpmColumn, propellerRpmVelColumn, propellerRpmAccColumn (4 character strings)

"propellerRpmColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
propellerRpmColumn	Column of propeller RPM graph (default Left).
propellerRpmVelColumn	Column of propeller RPM rate of change graph (default Hide).
propellerRpmAccColumn	Column of propeller RPM acceleration graph (default Hide).

Record (33f), Column Options for Azimuthing Propeller Deflections

This record is optional if a plot is being specified.

"aziPropellerDeflectColumns", aziPropellerDeflectColumn, aziPropellerDeflectVelColumn, aziPropellerDeflectAccColumn (4 character strings)

"aziPropellerDeflectColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
aziPropellerDeflectColumn	Column of rudder deflection graph (default Left).
aziPropellerDeflectVelColumn	Column of rudder deflection velocity graph (default Left).
aziPropellerDeflectAccColumn	Column of rudder deflection velocity graph (default Hide).

Record (33g), Column Options for Azimuthing Propeller RPMs

This record is optional if a plot is being specified.

"aziPropellerRpmColumns", aziPropellerRpmColumn, aziPropellerRpmVelColumn, aziPropellerRpmAccColumn (4 character strings)

"aziPropellerRpmColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
aziPropellerRpmColumn	Column of azimuthing propeller RPM graph (default Left).
aziPropellerRpmVelColumn	Column of azimuthing propeller RPM rate of change graph (default Hide).
aziPropellerRpmAccColumn	Column of azimuthing propeller RPM acceleration graph (default Hide).

Record (33h), Column Options for U-tube Tank Displacements

This record is optional if a plot is being specified.

"uTubeTankColumns", uTubeTankDispColumn, uTubeTankVelColumn, uTubeTankAccColumn (4 character strings)

"uTubeTankColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
uTubeTankDispColumn	Column of U-tube tank fluid displacement graph (default Left).
uTubeTankVelColumn	Column of U-tube tank fluid velocity graph (default Left).
uTubeTankAccColumn	Column of U-tube tank acceleration velocity graph (default Hide).

Record (33i), End of Appendage Time Series Plot Data

"end appendagePlots" (1 character string with 2 words)

Record (34), End of Ship Motion Simulation Ship Data

"end SM3DFreeMo3"(1 character string with 2 words)

B.2 Sample Input File for SM3DFreeMo3

```
begin SM3DFreeMo3
label Generic frigate
shipDBFileName genFrigShipForMotionDB.bin
lengthData 120.000 20.000
loadCondition 1025.000 4.200 0.000 6.000  0.0000
timeSeriesFileName genFrigTimeSeries.bin
seawayCalmOption Seaway
seawayFileName bretSeaState5Seaway.xml
timeParameters 0.2 0 20 20
hullForceNonLinearOption Linear
dispsFixed0MDeg 0 0 0 0 0 0
speed0Knots 20
rpmsPropellers0 166.5 166.5
begin maneuvers
    SetRpm All 166.5
    SetRudderCourse All 0
    ElapsedTime 100
end maneuvers
outTimeIntervals 0.4 10
outTimeSeries Disp Vel Acc
outAppendage Rudder Prop NoAziProp NoUTubeTank
plotOutOption noPlots
end SM3DFreeMo3
```

B.3 Sample Output File for SM3DFreeMo3 (Time Series Data Removed)

```
Program SM3DFreeMo3
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-09-11 8:21:25 AM
Run label:
Generic frigate


**** ECHO OF USER INPUT ****


Input ship database file name:
genFrigShipForMotionDB.bin
Label   : Generic frigate
Created : November-09-11 8:19:55 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.ShipForMotionDB

Ship Length Data
Length between perpendiculars :   120.000 m
Station of aft perpendicular  :    20.000

Ship Loading Condition
Water density : 1025.000 kg/m3
Draft of baseline at midships       :     4.200 m
Trim of baseline by stern           :     0.000 m
Height of CG above baseline, KG     :     6.000 m
Correction to metacentric height GM :     0.000 m

Output motion time series file name:
genFrigTimeSeries.bin
Seaway calm option : Seaway

Seaway file name:
bretSeaState5Seaway.xml
Label   : Hs = 3.25 m, Tp = 9.7 s, Bretschneider spectrum
Created : November-09-11 8:21:26 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.DeepSeaway.FixedMultiSeaway


Time parameters
```

```
Time step                         :        0.200 s
Initial time                      :        0.000 s
End of wave ramp function         :       20.000 s
Beginning of statistics sampling :       20.000 s

Option for nonlinear buoyancy and incident wave forces : Linear

Initial ship position
xf      :     0.000 m (+ north)
yf      :     0.000 m (+ west)
Heave   :     0.000 m (+ up, relative to calm water position)
Roll    :     0.000 deg (+ port up)
Pitch   :     0.000 deg (+ bow down)
Heading :     0.000 deg (0 north, 90 east)

Initial ship speed :       20.000 knots

Initial ship velocity components
xf velocity      :    10.300 m/s   (+ north)
yf velocity      :     0.000 m/s   (+ west)
Heave velocity   :     0.000 m/s   (+ up, relative to calm water position)
Roll velocity    :     0.000 deg/s (+ port up)
Pitch velocity   :     0.000 deg/s (+ bow down)
Heading velocity :     0.000 deg/s (0 north, 90 east)
Initial rudder deflections (deg) (default)
   0.000
Initial rudder velocities (deg/s) (default)
   0.000
Initial propeller RPMs (input)
 166.500  166.500

Beginning of maneuvering commands
SetRpm All 166.5
SetRudderCourse All 0
ElapsedTime 100
End of maneuvering commands


** Output options for time series

Output file time interval         : 0.400 s
Time interval for console message : 10.000 s
Options for writing time series to files
Displacements        : Disp
Velocities           : Vel
```

```
Accelerations        : Acc
Rudder deflections                   : Rudder
Propeller RPM                        : Prop
Azimuth propeller deflections && RPM : NoAziProp

** Output plot options

Plot output option : NoPlots

**** SHIP LOADING CONDITION ****

Load Condition Properties for Trimmed Ship

Summary of hydrostatic properties
Number of panels on port side        :         613
Total number of panels               :        1226
Length between perpendiculars        :     120.000 m
Draft of baseline at midships        :       4.200 m
Trim of baseline by stern            :       0.000 m
Beam based on maximum y value        :      14.111 m
Volume                               :    3622.358 m3
Water density                        :    1025.000 kg/m3
Mass                                 : 3712916.723463 kg
Distance from FP to X origin (m)     :      61.750 m
(Origin located at LCG)
Station of X origin                  :      10.292
Center of buoyancy wrt waterline     :      -1.614 m
Wetted surface area                  :    1753.438 m2
Waterplane area                      :    1344.310 m2
X value of center of floatation      :      -5.022 m
Integral of waterplane area*X**2     :  1234204.219 m4
Integral of waterplane area*Y**2     :    17543.814 m4
KG, height of CG above baseline      :       6.000 m
Height of CG above waterline         :       1.800 m
Metacentric height from hydrostatics :       1.430 m

Inertial Properties

Inertia matrix, units of kg, kg*m, and kg*m2
```

3712917	0	0	0	0	0
0	3712917	0	0	0	0
0	0	3712917	0	0	0
0	0	0	85545601	0	0
0	0	0	0	3341625051	0
0	0	0	0	0	3341625051

```
Roll radius of gyration  :     4.800 m
Pitch radius of gyration :    30.000 m
Yaw radius of gyration   :    30.000 m

Roll Metacentric Height Properities

Roll metacentric height from hull hydrostatics :     1.430 m
Correction due to sloshing tanks               :     0.000 m
Input correction to roll metacentric height    :     0.000 m
Corrected metacentric height                   :     1.430 m


Roll Properties at Zero Forward Speed

Roll added mass                        : 19662081.124976 kg*m**2
Nondimensional roll added mass A44/I44 :     0.230
Natural roll frequency                 :     0.703 rad/s
Natural roll period                    :     8.933 s


**** SHIP AUTOPILOT SETTINGS ****

Rudder autopilots for ShipAutopilot for freely maneuvering ship

Key   : Rudder
Label : Rudder
Maximum deflection        :    35.000 deg
Maximum velocity          :     3.000 deg/s
Maximum acceleration      :   Not set deg/s2
Response frequency        :     3.000 rad/s
Response damping          :     0.850 rad/s (fraction of critical)
Maximum time step         :     0.100 s
Acceleration attentuation :     0.010
(applied when displacement or velocity limits exceeded)
Autopilot gains
Displacement gains have units of deg/m and deg/deg
Velocity gains have units of deg/(m/s) and deg/(deg/s)
Yaw gains given relative to earth-fixed axes (+yaw is clockwise)
                           xf        yf    Heave     Roll    Pitch      Yaw

Displacement gains :    0.000     0.000    0.000    0.000    0.000   -4.000
Velocity gains     :    0.000     0.000    0.000    0.000    0.000   -8.000
Integration gains  :    0.000     0.000    0.000    0.000    0.000    0.000
Integration time   : 0.000 s
```

```
**** INITIALIZING FreeShipInSeawayTD OBJECT ****

CPU time for initialization of FreeShipInSeawayTD :        6.158 s

**** SIMULATING SHIP MOTIONS ****

Executing command at time 0.000 s
SetRpm All 166.5
Executing command at time 0.000 s
SetRudderCourse All 0
Executing command at time 0.000 s
Simulated time           :      100.000 s
CPU time                 :        0.318 s
Ratio CPU/simulated time :        0.003

**** COMPUTED SHIP MOTIONS ****

Time series summary
Beginning and end times for statistics(s)       20.200      100.000
Displacements, xf and yf in earth-fixed axes
Mode                            Mean       Dev       Max       Min    tz (s)
xf (m)                       611.201   233.547  1015.486   206.201     0.000
yf (m)                         0.000     0.000     0.000     0.000     6.164
heave (m)                      0.002     0.581     1.511    -1.626     6.050
roll (deg)                     0.000     0.000     0.000     0.000     7.280
pitch (deg)                    0.023     1.174     3.274    -3.254     5.240
heading (to) (deg)             0.000     0.000     0.000     0.000     5.569
Rudder deflections (deg)
Rudder                         0.000     0.000     0.000     0.000     5.554
Propeller RPM
PortPropeller                166.500     0.000   166.500   166.500     0.000
StarboardPropeller           166.500     0.000   166.500   166.500     0.000

Velocities, uf and vf in earth-fixed axes
Mode                            Mean       Dev       Max       Min    tz (s)
uf (m/s2)                     10.141     0.106    10.445     9.880     7.040
vf (m/s2)                      0.000     0.000     0.000     0.000     5.569
heave (m/s2)                  -0.015     0.615     1.766    -1.557     5.200
roll (deg/s)                   0.000     0.000     0.000     0.000     7.018
pitch (deg/s)                  0.026     1.292     3.146    -3.720     5.214
heading (to) (deg/s)           0.000     0.000     0.000     0.000     5.569
Rudder velocities (deg/s)
Rudder                         0.000     0.000     0.000     0.000     5.554
```

Ship speed along instantaneous heading

Speed (m/s)	10.141	0.106	10.445	9.880	7.040

Accelerations, xf and yf acceleration in earth-fixed axes

Mode	Mean	Dev	Max	Min	tz (s)
acc-xf (deg/s2)	0.002	0.100	0.245	-0.251	5.569
acc-yf (deg/s2)	0.000	0.000	0.000	0.000	4.494
heave (deg/s2)	-0.005	0.684	1.898	-1.841	5.229
roll (deg/s2)	0.000	0.000	0.000	0.000	6.050
pitch (deg/s2)	-0.018	1.480	4.037	-4.131	4.840
heading (to) (deg/s2)	0.000	0.000	0.000	0.000	5.093

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Annex C: Files for Motions in a Regular Seaway with SM3DSeakeepRegular3

C.1 Format of Input File for SM3DSeakeepRegular3

Record (1), Beginning Record

"begin SM3DSeakeepRegular3"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText (character string)

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"end note" (1 character string with 2 words)

Record (4), Input Ship Database File Name

"shipDBFileName", shipDBFileName (2 character strings)

"shipDBFileName"	Record tag.
shipDBFileName	Name of input ship database file in .NET binary serialization format. This file must have been created using program SM3DBuildShip3.

Record (5), Length Data

"lengthData", lpp, stationAP (1 character string, 2 floats)

"lengthData"	Record tag.
lpp	Ship length between perpendiculars (m)
stationAP	Station number of the aft perpendicular. This value is typically 20.0
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 m for length, and 0.001 for the station of the aft perpendicular. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (6), Ship Loading Condition

"loadCondition", waterDensity, draftBlMid, trimBlStern, shipKG, correctionGM (1 character string, 5 floats)

"loadCondition"	Record tag.
waterDensity	Water density ρ (kg/m^3).
draftBlMid	Draft of baseline at midships (m).
trimBlStern	Trim of baseline by stern (m).
shipKG	Height of centre of gravity above baseline (m).
correctionGM	Correction to metacentric height (m).
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 kg/m^3 for density, and 0.001 m for draft, trim, height of CG, and metacentric height. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (7), Beginning of Rudder Autopilot Settings

Records (7) to (7e) are optional.

"begin rudderAutopilotSettings" (2 character strings)

Note: Records (7) to (7e) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (7) to (7e), Records (7a) to (7d) can be repeated an arbitrary number of times to set rudder autopilot parameters as required.

Record (7a), Rudder Key for Autopilot Settings

"keyRudder" keyRudder (2 character strings)

This Record must follow Record (7) if autopilot settings are being given as input.

"keyRudder"	Record tag.
keyRudder	Key of rudder for which autopilot settings are being specified. If the rudder key is set to "All", then the input autopilot settings are applied to all rudders.

Record (7b), Rudder Autopilot Control Parameters

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"controlParam", deflectMaxDeg, velMaxDeg, accMaxDeg, freqResponse, dampResponse, dtMax (1 character string, 6 floats)

"controlParam"	Record tag.
deflectMaxDeg	Maximum rudder deflection angle (deg). This value is typically set to 35°.
velMaxDeg	Maximum rudder deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
accMaxDeg	Maximum rudder acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
freqResponse	Undamped response frequency of rudder autopilot.
dampResponse	Damping of rudder autopilot as a fraction of critical damping. This value is typically between 0.5 and 1.0.
dtMax	Maximum time increment for time stepping of rudder motions. This parameter doesn't affect frequency domain computations with SM3DSeakeepRegular.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7c), Rudder Autopilot Displacement Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"dispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"dispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless rudder roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7d), Rudder Velocity Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"velGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"velGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This should be typically 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This should be typically 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless rudder stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7e), End of Rudder Autopilot Settings

"end rudderAutopilotSettings" (2 character strings)

Record (8), Beginning of Azimuthing Propeller Force Slopes

Records (8) to (8c) are required if the ship has azimuthing propellers.

"begin aziPropellerForceSlopes" (2 character strings)

Record (8a), Key of Azimuthing Propeller for Force Slopes

Records (8a) to (8b) are required for each azimuthing propeller.

"keyAziPropeller" keyAziPropeller (2 character strings)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller.

Record (8b), Ship Speed and Azimuthing Propeller Force Slopes

This record can be repeated an arbitrary number of times after Record (8a). Note that ship speeds must be in ascending order.

"aziPropellerForceSlopes", speedAziPropeller, deflectForceSlopeDeg, normalForceSlopeDeg (1 character string, 3 floats)

"aziPropellerForceSlopes"	Record tag.
speedAziPropeller	Ship speed (m/s) corresponding to force slopes.
deflectForceSlopeDeg	Deflection force slope $\partial F/\partial \delta$ (N/deg) for azimuthing propeller, where F is the force perpendicular to the longitudinal axis of the ship and δ is the deflection angle of the propeller. This term is typically greater than zero, and includes contributions from both the propeller thrust and the force normal to the propeller axis when the propeller has a deflection angle.
normalForceSlopeDeg	Normal force slope $\partial F^N/\partial \alpha$ (N/deg) for azimuthing propeller, where F^N is the force normal to the propeller and α is the flow angle of attack. This term is typically greater than zero and somewhat less than the previous term deflectForceSlopeDeg ($\partial F/\partial \delta$).
Note:	The above required input terms are given in the output from SM3DBuildShip3.

Record (8c), End of Azimuthing Propeller Force Slopes

This record is required if the ship has azimuthing propellers.

"end aziPropellerForceSlopes" (2 character strings)

Record (9), Beginning of Azimuthing Propeller Deflection Controller Settings

Records (9) to (9e) are optional.

"begin aziPropellerDeflectControllerSettings" (2 character strings)

Note: Records (9) to (9e) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (9) to (9e), Records (9a) to (9d) can be repeated an arbitrary number of times to set azimuthing propeller controller parameters as required.

Record (9a), Azimuthing Propeller Key for Controller Settings

This record must follow Record (9) if controller settings are being given as input.

"keyAziPropeller" keyAziPropeller (1 character string, 1 integer)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller for which controller settings are being specified. If this key to set to "All", then the input controller settings are applied to all azimuthing propellers.

Record (9b), Azimuthing Propeller Deflection Controller Parameters

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a).

"deflectControlParam", deflectMaxDeg, deflectVelMaxDeg, deflectAccMaxDeg, deflectFreqResponse, deflectDampResponse, deflectDtMax (1 character string, 6 floats)

"deflectControlParam"	Record tag.
deflectMaxDeg	Maximum deflection angle (deg). This value is typically set to 35°.
deflectVelMaxDeg	Maximum deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
deflectAccMaxDeg	Maximum deflection acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
deflectFreqResponse	Undamped response frequency of deflection controller.
deflectDampResponse	Damping of deflection controller as a fraction of critical damping. This value is typically between 0.5 and 1.0.
deflectDtMax	Maximum time increment for time stepping of azimuthing propeller deflections. This parameter doesn't affect frequency domain computations with SM3DSeakeepRegular.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9c), Azimuthing Propeller Deflection Controller Displacement Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a)

"deflectDispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"deflectDispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a ship using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9d), Azimuthing Propeller Deflection Controller Velocity Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a).

“deflectVelGains”, surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

“deflectVelGains”	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a ship using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9e), End of Azimuthing Propeller Controller Settings

“end aziPropellerDeflectControllerSettings” (2 character strings)

Record (10), Output Options

“outOptions”, outRudderRaoOption, outAziPropRaoOption, outUTubeTankRaoOption, outRollDampOption (5 character strings)

“outOptions”	Record tag.
outRudderRaoOption	Option for writing rudder motions values: RudderRao - Rudder motions are written to output. NoRudderRao - Rudder motions are not written to output.
outAziPropRaoOption	Option for writing azimuthing propeller deflections: AziPropRao - Azimuthing propeller deflections are written to output. NoAziPropRao - Azimuthing propeller deflections are not written to output.
outUTubeTankRaoOption	Option for writing U-tube tank fluid displacements: UTubeTankRao - U-tube tank fluid displacements are written to output. NoUTubeTankRao - U-tube tank fluid displacements are not written to output.
outRollDampOption	Option for writing roll damping values: RollDamp - Roll damping coefficients are written to output. NoRollDamp - Roll damping coefficients are not written to output.

Record (11), Output Response Amplitude Operator File Name for Post-Processing

"outMoDefRaoPprOption", outMoDefRaoPprOption (2 character strings)

"outMoDefRaoPprOption"	Record tag.
outMoDefRaoPprOption	Option for output of data file with motion and appendage deflections response amplitude operators for post-processing. MotDefRaoPpr - Motion and appendage deflection RAOs are written to a file in .NET binary format. NoMoDefRaoPpr - Motion and appendage deflection RAOs are not written to a file in .NET binary format.

Record (12), Output Response Amplitude Operator File Name

This record should only be given if outMoDefRaoPprOption in Record (11) is set to MoDefRaoPpr.

"moDefRaoPprFileName", moDefRaoPprFileName (2 character strings)

"moDefRaoPprFileName"	Record tag.
moDefRaoPprFileName	Name of output file for response amplitude operators in .NET binary format.

Record (13), Minimum Wave Encounter Frequency

"enFreqMinMotion", enFreqMinMotion (1 character string, 1 float)

"enFreqMinMotion"	Record tag.
enFreqMinMotion	Minimum wave encounter frequency for ship motion predictions. If the combination of ship speed, heading, and wave frequency gives an encounter frequency less than this value, then the wave frequency is shifted. This variable is used to avoid large amplitude motions at very low encounter frequencies. A value of approximately $0.3\sqrt{g/L}$ is recommended.

Record (14a), Ship Speed Range in m/s

One of Records (14a) to (14f) must be given.

"speedRange", speedMin, speedMax, speedInc (1 character string, 3 floats)

"speedRange"	Record tag.
speedMin	Minimum ship speed (m/s).
speedMax	Maximum ship speed (m/s).
speedInc	Increment for ship speed (m/s).

Record (14b), Ship Speeds in m/s

One of Records (14a) to (14f) must be given.

"speeds", speeds (1 character string, array of floats)

"speeds"	Record tag.
speeds	Array of ship speeds (m/s).

Record (14c), Ship Speed Range in Knots

One of Records (14a) to (14f) must be given.

"speedKnotsRange", speedKnotsMin, speedKnotsMax, speedKnotsInc (1 character string, 3 floats)

"speedKnotsRange"	Record tag.
speedKnotsMin	Minimum ship speed (knots).
speedKnotsMax	Maximum ship speed (knots).
speedKnotsInc	Increment for ship speed (knots).

Record (14d), Ship Speeds in Knots

One of Records (14a) to (14f) must be given.

"speedsKnots", speedsKnots (1 character string, array of floats)

"speedsKnots"	Record tag.
speedsKnots	Array of ship speeds (knots).

Record (14e), Froude Number Range

One of Records (14a) to (14f) must be given.

"FroudeRange", froudeMin, froudeMax, froudeInc (1 character string, 3 floats)

"FroudeRange"	Record tag.
froudeMin	Minimum Froude number.
froudeMax	Maximum Froude number.
froudeInc	Froude number increment.

Record (14f), Ship Froude Numbers

One of Records (14a) to (14f) must be given.

"Froudes", froudes (1 character string, array of floats)

"Froudes"	Record tag.
froudes	Array of ship Froude numbers.

Record (15a), Range of Sea Directions Relative to the Ship

One of Records (15a) or (15b) must be given.

"seaDirDegRange", seaDirDegMin, seaDirDegMax, seaDirDegInc (1 character string, 3 floats)

"seaDirDegRange"	Record tag.
seaDirDegMin	Minimum sea direction relative to ship (deg).
seaDirDegMax	Maximum sea direction relative to ship (deg).
seaDirDegInc	Increment sea direction relative to ship (deg).

Record (15b), Sea Directions Relative to the Ship

One of Records (15a) or (15b) must be given.

"seaDirsDeg", seaDirsDeg (1 character string, array of floats)

"seaDirsDeg"	Record tag.
seaDirsDeg	Array of sea directions relative to the ship (deg) .

Record (16a), Range of Incident Wave Frequencies

One of Records (16a) or (16b) must be given.

“waveFreqRange”, waveFreqMin, waveFreqMax, waveFreqInc (1 character string, 3 floats)

“waveFreqRange”	Record tag.
waveFreqMin	Minimum incident wave frequency (rad/s).
waveFreqMax	Maximum incident wave frequency (rad/s).
waveFreqInc	Increment for incident wave frequency (rad/s).

Record (16b), Incident Wave Frequencies

One of Records (16a) or (16b) must be given.

“waveFreqs”, waveFreqs (1 character string, array of floats)

“waveFreqs”	Record tag.
waveFreqs	Array of increasing incident wave frequencies (rad/s).

Record (17), Input Wave Amplitude Option

“waveAmpOption”, waveAmpOption (2 character strings)

“waveAmpOption”	Record tag.
waveAmpOption	Option for input wave amplitudes as a function of wave frequency: ConstantAmplitude - All waves have the same amplitude a. ConstantSteepness - All waves have the same steepness H/λ. VariableAmplitude - Wave amplitude a varies with frequency.

Record (17a), Wave Amplitude

This Record must be given if waveAmpOption is set to ConstantAmplitude in Record (17).

“waveAmp”, waveAmp (1 character string, 1 float)

“waveAmp”	Record tag.
waveAmp	Wave amplitude at all wave frequencies (m).

Record (17b), Wave Steepness

This Record must be given if waveAmpOption is set to ConstantSteepness in Record (17).

"waveSteepness", waveSteepness (1 character string, 1 float)

"waveSteepness" Record tag.

waveSteepness Wave steepness H/λ at all wave frequencies. The wave slope ka is related to the wave steepness as follows:

$$k\,a \;=\; \pi\,H/\lambda \tag{C.1}$$

Record (17c), Wave Amplitudes

This record must be given if waveAmpOption is set to VariableAmplitude in Record (17).

"waveAmps", waveAmps (1 character string, array of floats)

"waveAmps" Record tag.

waveAmps Wave amplitudes for wave frequencies. The number of wave amplitudes must correspond to the number of wave frequencies given by Record (16a) or Record (16b).

Record (18), Beginning of Seakeeping Position Data

This record is optional.

"begin seakeepPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (18a) to (18c) giving seakeeping position parameters. Record (18d) must follow at the end of seakeeping position data.

Record (18a), Seakeeping Position Label

This record is required if a seakeeping position is being specified.

"labelPos", labelPos (2 character strings)

"labelPos" Record tag.

labelPos Label for seakeeping position. This can include spaces.

Record (18b), Seakeeping Position Location

This record is required if a seakeeping position is being specified.

"locationPos", stationPos, yPos, zBlPos (1 character string, 3 floats)

"locationPos"	Record tag.
stationPos	Station for seakeeping position. Station 0 is at the fore perpendicular.
yPos	Lateral coordinate (+ port) relative to ship centreline (m).
zBlPos	Vertical coordinate (+ up) relative to ship baseline (m).

Record (18c), Option for Including Radiation and Diffraction in Relative Vertical Motion

This record is optional if a seakeeping position is being specified.

"relMoRadDifOption", relMoRadDifOption (2 character strings)

"relMoRadDifOption"	Record tag.
relMoRadDifOption	Option for including radiation and diffraction in relative vertical motion: NoRadDif - Wave radiation and diffraction are not considered when evaluating relative wave motion (default).

Record (18d), End of Seakeeping Position Data

This record is required if Record (18) is present.

"end seakeepPositions" (1 character string with 2 words)

Record (19), Beginning of Wave Kinematics Position Data

This record is optional.

"begin waveKinPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (19a) to (19c) giving wave kinematics position parameters. Record (19d) must follow at the end of wave kinematics position data.

Record (19a), Wave Kinematics Position Label

This record is required if a wave kinematic position is being specified.

"labelWaveKin", labelWaveKin (2 character strings)

"labelWaveKin"	Record tag.
labelWaveKin	Label for wave kinematic position. This can include spaces.

Record (19b1), Wave Kinematics Position Station and Elevation Relative to Baseline

One of Record (19b1), (19b2), or (19b3) is required if a wave kinematics position is being specified.

"stationYZBlWaveKin", stationWaveKin, yWaveKin, zBlWaveKin (1 character string, 3 floats)

"stationYZBlWaveKin"	Record tag.
stationWaveKin	Station for wave kinematic position. Station 0 is at the fore perpendicular.
yWaveKin	Lateral coordinate (+ port) relative to ship centreline (m).
zBlWaveKin	Vertical coordinate (+ up) relative to ship baseline (m). If this position is above the calm waterline for the trimmed ship, then it is moved to the calm waterline.

Record (19b2), Wave Kinematics Position Station and Elevation Relative to Calm Waterline

One of Record (19b1), (19b2), or (19b3) is required if a wave kinematics position is being specified.

"stationYZWlWaveKin", stationWaveKin, yWaveKin, zWlWaveKin (1 character string, 3 floats)

"stationYZWlWaveKin"	Record tag.
stationWaveKin	Station for wave kinematic position. Station 0 is at the fore perpendicular.
yWaveKin	Lateral coordinate (+ port) relative to ship centreline (m).
zWlWaveKin	Vertical coordinate (+ up) relative to the calm waterline (m).

Record (19b3), Wave Kinematics Position X Coordinate and Elevation Relative to Calm Waterline

One of Record (19b1), (19b2), or (19b3) is required if a wave kinematics position is being specified.

"xYZWlWaveKin", xWaveKin, yWaveKin, zWlWaveKin (1 character string, 3 floats)

"xYZWlWaveKin"	Record tag.
xWaveKin	x coordinate (+ forward, relative to ship CG) for wave kinematic position (m).
yWaveKin	Lateral coordinate (+ port) relative to ship centreline (m).
zWlWaveKin	Vertical coordinate (+ up) relative to the calm waterline (m).

Record (19c), Option for Including Radiation and Diffraction in Wave Kinematics

This record is optional if a wave kinematics position is being specified.

"waveKinRadDifOption", waveKinRadDifOption (2 character strings)

"waveKinRadDifOption"	Record tag.
waveKinRadDifOption	Option for including radiation and diffraction in wave kinematics: NoRadDif - Wave radiation and diffraction are not considered when evaluating wave kinematics (default).

Record (19d), End of Wave Kinematics Position Data

This record is required if Record (19) is present.

"end waveKinPositions" (1 character string with 2 words)

Record (20), Plot Output Option

"plotOutOption", plotOutOption (2 character strings)

"plotOutOption"	Record tag.
plotOutOption	Option for making plots of motion response amplitude operators: NoPlots - No plots are produced. ScreenFile - Plots are both plotted on the screen and to a file. Screen - Plots are only plotted on the screen. File - Plots are only written to a file.

Record (21), Beginning of Ship Motion RAO Plot Data

This record is optional.

"begin motionRaoPlots" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (21a) to (21h) giving plot parameters. Record (21i) must follow at the end of plot parameter data.

Record (21a), Motion RAO Plot Image File Name

This record is required if a plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (21b), Motion RAO Plot Image Format

This record is optional if a plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (21c), Motion RAO Plot Image Size

This record is optional if a plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 200 mm)

Record (21d1), Motion RAO Plot Speed in m/s

One of Records (21d1), (21d2), or (21d3) is required for each plot being specified.

"speed", speed (1 character string, 1 float)

"speed"	Record tag.
speed	Ship speed (m/s) for plotted RAOs. This speed should correspond to a speed specified for computations in one of Records (14a) to (14f).

Record (21d2), Motion RAO Plot Speed in Knots

One of Records (21d1), (21d2), or (21d3) is required for each plot being specified.

"speedKnots", speedKnots (1 character string, 1 float)

"speedKnots"	Record tag.
speedKnots	Ship speed (knots) for plotted RAOs. This speed must correspond to a speed specified for computations in one of Records (14a) to (14f).

Record (21d3), Motion RAO Plot Froude Number

One of Records (21d1), (21d2), or (21d3) is required for each plot being specified.

"Froude", Froude (1 character string, 1 float)

"Froude"	Record tag.
Froude	Ship forward speed Froude number for plotted RAOs. This speed should correspond to a speed specified for computations in one of Records (14a) to (14f).

Record (21e), Motion RAO Plot Sea Direction

This record is required for each plot being specified.

"seaDirDeg", seaDirDeg (1 character string, 1 float)

"seaDirDeg"	Record tag.
seaDirDeg	Sea direction (deg) relative to ship for plotted RAOs. This sea direction must correspond to a sea direction specified for computations in Record (15a) or (15b).

Record (21f), Option for Longitudinal and/or Lateral Modes

This record is optional if a plot is being specified.

"longLatOption", longLatOption (2 character strings)

"longLatOption"	Record tag.
longLatOption	Option for plotting modes.
	LongLat - Longitudinal and lateral and modes will be shown with longitudinal modes in the left column and lateral modes in the right column (default).
	Long - Longitudinal modes will be shown in a single column.
	Lat - Lateral modes will be shown in a single column.

Record (21g), Column Options for Longitudinal Modes

This record is optional if a plot is being specified

"longColumns", surgeColumn, heaveColumn, pitchColumn (3 character strings)

"longColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
surgeColumn	Column of surge graph.
heaveColumn	Column of heave graph.
pitchColumn	Column of pitch graph.
Note:	The values in this record will override values set based on longLatOption in Record (21f).

Record (21h), Column Options for Lateral Modes

This record is optional if a plot is being specified.

"latColumns", swayColumn, rollColumn, yawColumn, deflectColumn (5 character strings)

"latColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
swayColumn	Column of sway graph.
rollColumn	Column of roll graph.
yawColumn	Column of yaw graph.
deflectColumn	Column of graph with rudder and/or azimuthing propeller deflection angle RAOs.
Note:	The values in this record will override values set based on longLatOption in Record (21f).

Record (21i), End of Ship Motion RAO Plot Data

"end motionRaoPlots" (1 character string with 2 words)

Record (22), End Record

"end SM3DSeakeepRegular3"(1 character string with 2 words)

C.2 Sample Input File for SM3DSeakeepRegular3

```
begin SM3DSeakeepRegular3
label Generic frigate
shipDBFileName genFrigShipForMotionDB.bin
lengthData 120.000 20.000
loadCondition 1025.000 4.200 0.000 6.000 0.0000
outOptions RudderRao NoAziPropRao NoUTubeTankRao RollDamp
outMoDefRaoPprOption MoDefRaoPpr
moDefRaoPprFileName genFrigSeakeepRegularMoDefRaoDB.bin
enFreqMinMotion 0.1
speedKnotsRange 0 30 10
seaDirDegRange 0 180 15
waveFreqRange 0.2 2 0.05
waveAmpOption ConstantSteepness
waveSteepness 0.02
begin seakeepPositions
labelPos Seakeeping position
    locationPos 3 2 12
    relMoRadDifOption NoRadDif
end seakeepPositions
plotOutOption NoPlots
end SM3DSeakeepRegular3
```

C.3 Sample Output File for SM3DSeakeepRegular3 (Motions Given for Only One Speed and Heading Combination)

```
Program SM3DSeakeepRegular3
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-10-11 9:07:15 AM
Run label:
Generic frigate

**** ECHO OF USER INPUT ****

Input ship for motion database file name:
genFrigShipForMotionDB.bin
Label   : Generic frigate
Created : November-09-11 8:19:55 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.ShipForMotionDB

Ship Length Data
Length between perpendiculars :   120.000 m
Station of aft perpendicular  :    20.000

Ship Loading Condition
Water density : 1025.000 kg/m3
Draft of baseline at midships       :     4.200 m
Trim of baseline by stern           :     0.000 m
Height of CG above baseline, KG     :     6.000 m
Correction to metacentric height GM :     0.000 m

Output rudder motion option : RudderRao
Output azimuthing propeller deflection option : NoAziPropRao
Output U-tube tank fluid displacement option : NoUTubeTankRao
Output roll damping option : RollDamp

Output motion and deflection RAO post-processing file option : MoDefRaoPpr
File name with RAOs for post-processing :
genFrigSeakeepRegularMoDefRaoDB.bin

Minimum wave encounter frequency for predicting ship motions : 0.100 rad/s

Speed range
Minimum   :    0.000 knots
Maximum   :   30.000 knots
Increment :   10.000 knots

Sea direction range
Minimum   :    0.000 deg
Maximum   :  180.000 deg
```

```
Increment :   15.000 deg

Incident wave frequency range
Minimum   :    0.200 rad/s
Maximum   :    2.000 rad/s
Increment :    0.050 rad/s

Input wave amplitude option : ConstantSteepness
Wave steepness for all frequencies : 0.020

Incident wave conditions
Frequency      Amplitude   Steepness     Slope
 (rad/s)         (m)
    0.200       15.403     0.020000     0.062832
    0.250        9.858     0.020000     0.062832
    0.300        6.846     0.020000     0.062832
    0.350        5.030     0.020000     0.062832
    0.400        3.851     0.020000     0.062832
    0.450        3.043     0.020000     0.062832
    0.500        2.465     0.020000     0.062832
    0.550        2.037     0.020000     0.062832
    0.600        1.711     0.020000     0.062832
    0.650        1.458     0.020000     0.062832
    0.700        1.257     0.020000     0.062832
    0.750        1.095     0.020000     0.062832
    0.800        0.963     0.020000     0.062832
    0.850        0.853     0.020000     0.062832
    0.900        0.761     0.020000     0.062832
    0.950        0.683     0.020000     0.062832
    1.000        0.616     0.020000     0.062832
    1.050        0.559     0.020000     0.062832
    1.100        0.509     0.020000     0.062832
    1.150        0.466     0.020000     0.062832
    1.200        0.428     0.020000     0.062832
    1.250        0.394     0.020000     0.062832
    1.300        0.365     0.020000     0.062832
    1.350        0.338     0.020000     0.062832
    1.400        0.314     0.020000     0.062832
    1.450        0.293     0.020000     0.062832
    1.500        0.274     0.020000     0.062832
    1.550        0.256     0.020000     0.062832
    1.600        0.241     0.020000     0.062832
    1.650        0.226     0.020000     0.062832
    1.700        0.213     0.020000     0.062832
    1.750        0.201     0.020000     0.062832
    1.800        0.190     0.020000     0.062832
    1.850        0.180     0.020000     0.062832
    1.900        0.171     0.020000     0.062832
    1.950        0.162     0.020000     0.062832
    2.000        0.154     0.020000     0.062832
```

```
Seakeeping Positions

Label              : Seakeeping position
Station            :     3.000
Lateral offset y   :     2.000 m (+ port)
Vertical offset zBl :   12.000 m (+ up, relative to baseline)
Option for including radiation and diffraction for relative motion : NoRadDif
                                                                      (input)

Plot output option : NoPlots

**** SHIP LOADING CONDITION ****

Load Condition Properties for Trimmed Ship

Summary of hydrostatic properties
Number of panels on port side       :          613
Total number of panels              :         1226
Length between perpendiculars       :      120.000 m
Draft of baseline at midships       :        4.200 m
Trim of baseline by stern           :        0.000 m
Beam based on maximum y value       :       14.111 m
Volume                              :     3622.358 m3
Water density                       :     1025.000 kg/m3
Mass                                : 3712916.723463 kg
Distance from FP to X origin (m)    :       61.750 m
(Origin located at LCG)
Station of X origin                 :       10.292
Center of buoyancy wrt waterline    :       -1.614 m
Wetted surface area                 :     1753.438 m2
Waterplane area                     :     1344.310 m2
X value of center of floatation     :       -5.022 m
Integral of waterplane area*X**2    :  1234204.219 m4
Integral of waterplane area*Y**2    :    17543.814 m4
KG, height of CG above baseline     :        6.000 m
Height of CG above waterline        :        1.800 m
Metacentric height from hydrostatics :       1.430 m

Inertial Properties

Inertia matrix, units of kg, kg*m, and kg*m2
   3712916.7          0.0          0.0          0.0          0.0          0.0
         0.0    3712916.7          0.0          0.0          0.0          0.0
         0.0          0.0    3712916.7          0.0          0.0          0.0
         0.0          0.0          0.0   85545601.3          0.0          0.0
         0.0          0.0          0.0          0.0 3341625051.1          0.0
         0.0          0.0          0.0          0.0          0.0 3341625051.1

Roll radius of gyration  :     4.800 m
Pitch radius of gyration :    30.000 m
Yaw radius of gyration   :    30.000 m
```

```
Roll Metacentric Height Properities

)Roll metacentric height from hull hydrostatics :     1.430 m
Correction due to sloshing tanks                :     0.000 m
Input correction to roll metacentric height     :     0.000 m
Corrected metacentric height                    :     1.430 m


Roll Properties at Zero Forward Speed

Roll added mass                         : 19548240.530169 kg*m**2
Nondimensional roll added mass A44/I44 :     0.229
Natural roll frequency                  :     0.704 rad/s
Natural roll period                     :     8.928 s


**** SHIP AUTOPILOT SETTINGS ****

Rudder Autopilots for Ship

Autopilot for ship with nominally steady speed and heading
Key   : Rudder
Label : Rudder
Maximum deflection   :    35.000 deg
Maximum velocity     :     3.000 deg/s
Maximum acceleration :   Not set deg/s2
Response frequency   :     3.000 rad/s
Response damping     :     0.850 rad/s (fraction of critical)
Maximum time step    :     0.100 s
Autopilot gains
Displacement gains have units of deg/m and deg/deg
Velocity gains have units of deg/(m/s) and deg/(deg/s)
Yaw gains given relative to earth-fixed axes (+yaw is clockwise)
                        Surge     Sway    Heave     Roll    Pitch      Yaw
Displacement gains :    0.000    0.000    0.000    0.000    0.000   -4.000
Velocity gains     :    0.000    0.000    0.000    0.000    0.000   -8.000


**** SEAKEEPING POSITION TRIM CONDITIONS ****

Label           : Seakeeping position
Station         :     3.000
x wrt ship CG   :    43.750 m
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
```

**** Motions in Regular Waves ****

Speed : 10.300 m/s (20.000 knots)
Froude number : 0.300
Sea direction : 150.000 deg (from, 180 deg head seas, 90 deg waves from port)
Surge, sway, and heave non-dimensionalized by wave amplitude
Roll, pitch, and yaw non-dimensionalized by wave slope ka

Wave freq	Enc freq	Surge		Sway		Heave		Roll		Pitch		Yaw	
(rad/s)	(rad/s)	Amp	Phase	Amp	Phase	Amp	Phase	Amp	Phase	Amp	Phase	Amp	Phase
0.200	0.236	0.631	94	0.422	84	1.001	0	0.710	129	0.878	269	0.353	152
0.250	0.307	0.577	93	0.396	88	1.005	0	0.550	113	0.872	268	0.244	166
0.300	0.382	0.540	92	0.370	89	0.990	0	0.536	98	0.893	267	0.199	174
0.350	0.461	0.498	90	0.356	91	0.988	360	0.488	65	0.904	265	0.187	187
0.400	0.546	0.466	86	0.339	93	0.979	2	0.643	31	0.947	261	0.179	193
0.450	0.634	0.430	82	0.323	92	0.962	3	0.887	322	0.980	257	0.204	196
0.500	0.727	0.361	75	0.286	89	0.990	4	0.894	265	0.955	250	0.191	188
0.550	0.825	0.286	69	0.234	90	1.017	3	0.646	233	0.903	242	0.156	186
0.600	0.927	0.220	63	0.194	91	1.022	1	0.502	216	0.838	235	0.129	187
0.650	1.034	0.159	54	0.150	94	1.028	356	0.391	209	0.766	226	0.102	191
0.700	1.146	0.100	43	0.111	97	0.983	345	0.305	201	0.664	215	0.082	195
0.750	1.262	0.053	23	0.075	103	0.837	329	0.227	198	0.538	200	0.060	201
0.800	1.382	0.023	338	0.043	114	0.522	307	0.162	193	0.378	182	0.045	209
0.850	1.507	0.019	265	0.022	133	0.166	297	0.101	185	0.200	158	0.030	218
0.900	1.637	0.017	244	0.013	195	0.099	33	0.054	173	0.059	131	0.019	235
0.950	1.771	0.012	258	0.013	237	0.154	30	0.024	132	0.020	321	0.011	260
1.000	1.910	0.012	288	0.015	261	0.108	25	0.023	65	0.038	298	0.009	298
1.050	2.053	0.012	297	0.011	280	0.069	19	0.031	46	0.037	283	0.007	325
1.100	2.201	0.010	298	0.008	316	0.028	27	0.034	38	0.024	273	0.006	349
1.150	2.353	0.005	301	0.006	3	0.007	83	0.027	37	0.013	265	0.004	10
1.200	2.510	0.001	79	0.008	38	0.014	153	0.019	40	0.002	288	0.003	49
1.250	2.671	0.004	116	0.007	56	0.014	161	0.008	51	0.002	78	0.002	98
1.300	2.837	0.005	120	0.005	86	0.007	168	0.004	123	0.003	66	0.003	131
1.350	3.008	0.004	121	0.002	135	0.003	161	0.006	171	0.002	74	0.002	146
1.400	3.183	0.001	120	0.004	192	0.002	306	0.008	180	0.001	129	0.001	170
1.450	3.363	0.001	310	0.004	207	0.003	15	0.006	167	0.000	107	0.000	255

1.500	3.547	0.003	308	0.003	213	0.003	62	0.004	147	0.001	135	0.001	325
1.550	3.735	0.002	303	0.002	154	0.003	19	0.004	102	0.001	321	0.001	337
1.600	3.929	0.001	223	0.003	95	0.004	13	0.005	79	0.001	343	0.001	347
1.650	4.127	0.001	27	0.004	84	0.006	107	0.003	67	0.002	95	0.000	281
1.700	4.329	0.003	26	0.004	80	0.014	116	0.002	55	0.004	107	0.000	178
1.750	4.536	0.001	352	0.001	63	0.007	88	0.001	95	0.002	80	0.000	173
1.800	4.747	0.001	276	0.001	252	0.005	6	0.002	129	0.001	0	0.000	170
1.850	4.963	0.001	264	0.002	237	0.003	325	0.001	135	0.001	311	0.000	57
1.900	5.184	0.000	239	0.001	204	0.003	246	0.001	135	0.001	240	0.000	9
1.950	5.409	0.000	48	0.002	137	0.002	179	0.001	146	0.000	171	0.000	350
2.000	5.639	0.000	102	0.003	114	0.003	122	0.002	146	0.001	104	0.000	287

**** Rudder Deflections in Regular Waves ****

Speed : 10.300 m/s (20.000 knots)
Froude number : 0.300
Sea direction : 150.000 deg (from, 180 deg head seas, 90 deg waves from port)
Rudder deflections non-dimensionalized by wave slope ka
Rudder keys and labels

Key	Label
Rudder	Rudder

Wave freq Rudder deflections and phases

Wave freq	Rudder Amp	Rudder Phase (deg)
0.200	1.559	169
0.250	1.141	187
0.300	0.996	199
0.350	1.006	215
0.400	1.045	223
0.450	1.294	227
0.500	1.310	220
0.550	1.165	218

```
      0.600          1.037 219
      0.650          0.884 221
      0.700          0.760 224
      0.750          0.602 229
      0.800          0.476 234
      0.850          0.332 241
      0.900          0.222 255
      0.950          0.138 277
      1.000          0.113 312
      1.050          0.091 335
      1.100          0.084 357
      1.150          0.054  14
      1.200          0.040  49
      1.250          0.029  95
      1.300          0.036 125
      1.350          0.026 136
      1.400          0.016 157
      1.450          0.002 239
      1.500          0.012 306
      1.550          0.013 315
      1.600          0.010 322
      1.650          0.002 253
      1.700          0.006 148
      1.750          0.006 140
      1.800          0.004 135
      1.850          0.002  20
      1.900          0.004 330
      1.950          0.002 309
      2.000          0.001 243


 **** Roll Damping ****

 Ship speed             :    10.300 m/s
 Relative sea direction :     150.0 deg
 Speed         :    10.300 m/s (20.000 knots)
```

Froude number : 0.300
Sea direction : 150.000 deg (from, 180 deg head seas, 90 deg waves from port)
Roll damping non-dimensionalized by critical roll damping at forward speed
Critical roll damping : 147962152.002 Nm/(rad/s)

Wave freq (rad/s)	Enc freq (rad/s)	Roll amp (deg)	Roll damping components Total	Hull Radiation	Hull Viscous	Hull Maneuver	Appendage Lift	Appendage Viscous	Added mass
0.200	0.236	2.556	0.085	0.010	0.000	0.004	0.058	0.013	0.212
0.250	0.307	1.980	0.089	0.010	0.000	0.004	0.058	0.016	0.214
0.300	0.382	1.929	0.093	0.010	0.000	0.004	0.058	0.020	0.216
0.350	0.461	1.756	0.097	0.011	0.000	0.004	0.058	0.024	0.219
0.400	0.546	2.315	0.103	0.012	0.000	0.004	0.058	0.029	0.223
0.450	0.634	3.194	0.112	0.014	0.000	0.004	0.058	0.036	0.227
0.500	0.727	3.219	0.122	0.018	0.000	0.004	0.058	0.041	0.229
0.550	0.825	2.324	0.130	0.024	0.000	0.004	0.058	0.044	0.228
0.600	0.927	1.808	0.140	0.030	0.000	0.004	0.058	0.048	0.224
0.650	1.034	1.407	0.152	0.037	0.000	0.004	0.058	0.052	0.218
0.700	1.146	1.098	0.162	0.044	0.000	0.004	0.058	0.055	0.210
0.750	1.262	0.818	0.170	0.050	0.000	0.004	0.058	0.058	0.199
0.800	1.382	0.582	0.177	0.054	0.000	0.004	0.058	0.060	0.189
0.850	1.507	0.365	0.159	0.054	0.000	0.004	0.058	0.042	0.179
0.900	1.637	0.193	0.141	0.055	0.000	0.004	0.058	0.024	0.171
0.950	1.771	0.086	0.127	0.053	0.000	0.004	0.058	0.012	0.165
1.000	1.910	0.081	0.125	0.051	0.000	0.004	0.058	0.012	0.161
1.050	2.053	0.113	0.129	0.049	0.000	0.004	0.058	0.018	0.159
1.100	2.201	0.121	0.128	0.046	0.000	0.004	0.058	0.020	0.158
1.150	2.353	0.098	0.123	0.043	0.000	0.004	0.058	0.017	0.157
1.200	2.510	0.069	0.115	0.040	0.000	0.004	0.058	0.013	0.157
1.250	2.671	0.031	0.106	0.038	0.000	0.004	0.058	0.006	0.157
1.300	2.837	0.015	0.100	0.035	0.000	0.004	0.058	0.003	0.157
1.350	3.008	0.023	0.096	0.029	0.000	0.004	0.058	0.005	0.159
1.400	3.183	0.028	0.100	0.031	0.000	0.004	0.058	0.007	0.159
1.450	3.363	0.022	0.098	0.030	0.000	0.004	0.058	0.006	0.160
1.500	3.547	0.015	0.096	0.030	0.000	0.004	0.058	0.004	0.160
1.550	3.735	0.015	0.096	0.029	0.000	0.004	0.058	0.004	0.161

1.600	3.929	0.018	0.102	0.034	0.000	0.004	0.058	0.005	0.161
1.650	4.127	0.012	0.106	0.040	0.000	0.004	0.058	0.004	0.164
1.700	4.329	0.007	0.110	0.045	0.000	0.004	0.058	0.002	0.168
1.750	4.536	0.005	0.095	0.031	0.000	0.004	0.058	0.002	0.160
1.800	4.747	0.006	0.077	0.012	0.000	0.004	0.058	0.002	0.150
1.850	4.963	0.004	0.077	0.013	0.000	0.004	0.058	0.001	0.155
1.900	5.184	0.002	0.072	0.009	0.000	0.004	0.058	0.001	0.157
1.950	5.409	0.005	0.066	0.001	0.000	0.004	0.058	0.002	0.156
2.000	5.639	0.007	0.041	-0.024	0.000	0.004	0.058	0.003	0.165

**** Motions at Seakeeping Positions in Regular Waves ****

Ship speed : 10.300 m/s
Relative sea direction : 150.0 deg

Label : Seakeeping position
Station : 3.000
y : 2.000 m
zBl : 12.000 m
All displacements non-dimensionalized by wave amplitude

Wave freq	Enc freq	Long disp		Lat disp		Vert disp		Rel vert disp	
(rad/s)	(rad/s)	Amp	Phase	Amp	Phase	Amp	Phase	Amp	Phase
0.200	0.236	0.608	94	0.436	90	1.015	9	0.016	34
0.250	0.307	0.543	93	0.396	96	1.044	14	0.044	14
0.300	0.382	0.491	92	0.357	101	1.075	20	0.075	19
0.350	0.461	0.431	90	0.334	112	1.150	26	0.154	13
0.400	0.546	0.376	87	0.339	125	1.305	33	0.313	21
0.450	0.634	0.312	82	0.435	129	1.489	37	0.525	20
0.500	0.727	0.220	77	0.436	116	1.696	37	0.824	13
0.550	0.825	0.125	74	0.336	114	1.910	35	1.211	8
0.600	0.927	0.046	86	0.262	117	2.070	32	1.616	4
0.650	1.034	0.038	200	0.197	124	2.207	25	2.099	359
0.700	1.146	0.093	209	0.141	136	2.187	15	2.496	352
0.750	1.262	0.126	199	0.094	153	1.955	1	2.679	343
0.800	1.382	0.122	185	0.069	187	1.425	344	2.393	336

0.850	1.507	0.082	168	0.060	221	0.766	329	1.751	338
0.900	1.637	0.027	159	0.067	248	0.240	333	1.213	358
0.950	1.771	0.018	291	0.066	264	0.147	62	1.122	30
1.000	1.910	0.033	294	0.063	279	0.200	83	1.167	53
1.050	2.053	0.036	286	0.048	288	0.209	82	1.206	72
1.100	2.201	0.027	279	0.033	305	0.151	80	1.146	93
1.150	2.353	0.015	272	0.014	322	0.087	81	1.069	118
1.200	2.510	0.002	275	0.010	55	0.026	118	1.023	146
1.250	2.671	0.004	106	0.014	105	0.014	199	1.013	175
1.300	2.837	0.006	99	0.019	122	0.022	224	1.021	204
1.350	3.008	0.005	97	0.012	129	0.019	238	1.019	234
1.400	3.183	0.002	110	0.005	171	0.005	280	1.005	265
1.450	3.363	0.001	333	0.006	305	0.003	294	1.003	298
1.500	3.547	0.002	299	0.014	312	0.006	337	1.006	331
1.550	3.735	0.002	303	0.012	313	0.007	109	0.998	6
1.600	3.929	0.002	327	0.009	315	0.014	145	0.997	42
1.650	4.127	0.004	76	0.003	244	0.014	273	0.986	78
1.700	4.329	0.009	84	0.008	172	0.042	285	0.959	117
1.750	4.536	0.004	61	0.006	187	0.021	257	0.996	157
1.800	4.747	0.003	333	0.004	233	0.014	174	1.013	196
1.850	4.963	0.002	290	0.002	324	0.008	128	0.997	237
1.900	5.184	0.002	235	0.005	354	0.010	61	0.993	281
1.950	5.409	0.001	165	0.005	347	0.003	355	1.003	324
2.000	5.639	0.002	104	0.003	338	0.008	270	0.999	8

Computation time : 3 s

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Annex D: Files for Motions in a Random Seaway with SM3DSeakeepRandom3

D.1 Format of Input File for SM3DSeakeepRandom3

Record (1), Beginning Record

"begin SM3DSeakeepRandom3"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText (character string)

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input. "end note" (1 character string with 2 words)

Record (4), Input Ship Database File Name

"shipDBFileName", shipDBFileName (2 character strings)

"shipDBFileName"	Record tag.
shipDBFileName	Name of input ship database file in .NET binary serialization format. This file must have been created using program SM3DBuildShip3.

Record (5), Length Data

"lengthData", lpp, stationAP (1 character string, 2 floats)

"lengthData"	Record tag.
lpp	Ship length between perpendiculars (m)
stationAP	Station number of the aft perpendicular. This value is typically 20.0
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 m for length, and 0.001 for the station of the aft perpendicular. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (6), Ship Loading Condition

“loadCondition”, waterDensity, draftBlMid, trimBlStern, shipKG, correctionGM (1 character string, 5 floats)

“loadCondition”	Record tag.
waterDensity	Water density (kg/m^3).
draftBlMid	Draft of baseline at midships (m).
trimBlStern	Trim of baseline by stern (m).
shipKG	Height of centre of gravity above baseline (m).
correctionGM	Correction to metacentric height (m).
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 kg/m^3 for density, and 0.001 m for draft, trim, height of CG, and metacentric height. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (7), Beginning of Rudder Autopilot Settings

Records (7) to (7e) are optional.

“begin rudderAutopilotSettings” (2 character strings)

Note: Records (7) to (7e) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (7) to (7e), Records (7a) to (7d) can be repeated an arbitrary number of times to set rudder autopilot parameters as required.

Record (7a), Rudder Key for Autopilot Settings

This Record must follow Record (7) if autopilot settings are being given as input.

“keyRudder” keyRudder (2 character strings)

“keyRudder”	Record tag.
keyRudder	Key of rudder for which autopilot settings are being specified. If the rudder key is set to “All”, then the input autopilot settings are applied to all rudders.

Record (7b), Rudder Autopilot Control Parameters

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"controlParam", deflectMaxDeg, velMaxDeg, accMaxDeg, freqResponse, dampResponse, dtMax (1 character string, 6 floats)

"controlParam"	Record tag.
deflectMaxDeg	Maximum rudder deflection angle (deg). This value is typically set to 35°
velMaxDeg	Maximum rudder deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
accMaxDeg	Maximum rudder acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
freqResponse	Undamped response frequency of rudder autopilot.
dampResponse	Damping of rudder autopilot as a fraction of critical damping. This value is typically between 0.5 and 1.0
dtMax	Maximum time increment for time stepping of rudder motions. This parameter doesn't affect frequency domain computations with SM3DSeakeepRandom3.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7c), Rudder Autopilot Displacement Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"dispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"dispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless rudder roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7d), Rudder Velocity Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"velGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"velGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless rudder stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7e), End of Rudder Autopilot Settings

"end rudderAutopilotSettings" (2 character strings)

Record (8), Beginning of Azimuthing Propeller Force Slopes

Records (8) to (8c) are required if the ship has azimuthing propellers.

"begin aziPropellerForceSlopes" (2 character strings)

Record (8a), Key of Azimuthing Propeller for Force Slopes

Records (8a) to (8b) are required for each azimuthing propeller.

"keyAziPropeller" keyAziPropeller (2 character strings)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller.

Record (8b), Ship Speed and Azimuthing Propeller Force Slopes

This record can be repeated an arbitrary number of times after Record (8a). Note that ship speeds must be in ascending order.

"aziPropellerForceSlopes", speedAziPropeller, swayForceDeflectSlopeDeg, heaveForceDeflectSlopeDeg (1 character string, 3 floats)

"aziPropellerForceSlopes"	Record tag.
speedAziPropeller	Ship speed (m/s) corresponding to force slopes.
swayForceDeflectSlopeDeg	Sway force deflection slope $\partial F_2/\partial\delta$ (N/deg) for azimuthing propeller. For a typical downward pointing azimuthing propeller (dihedral angle of $-90°$), this value will be negative.
heaveForceDeflectSlopeDeg	Heave force deflection slope $\partial F_3/\partial\delta$ (N/deg) for azimuthing propeller. For a typical downward pointing azimuthing propeller (dihedral angle of $-90°$), this value will be approximately 0.0.
Note:	The above required input terms are given in the output from SM3DBuildShip3.

Record (8c), End of Azimuthing Propeller Force Slopes

This record is required if the ship has azimuthing propellers.

"end aziPropellerForceSlopes" (2 character strings)

Record (9), Beginning of Azimuthing Propeller Deflection Controller Settings

Records (9) to (9e) are optional.

"begin aziPropellerDeflectControllerSettings" (2 character strings)

Note: Records (9) to (9e) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (9) to (9e), Records (9a) to (9d) can be repeated an arbitrary number of times to set azimuthing propeller controller parameters as required.

Record (9a), Azimuthing Propeller Key for Controller Settings

This record must follow Record (9) if controller settings are being given as input.

"keyAziPropeller" keyAziPropeller (1 character string, 1 integer)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller for which controller settings are being specified. If this key to set to "All", then the input controller settings are applied to all azimuthing propellers.

Record (9b), Azimuthing Propeller Deflection Controller Parameters

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a)

"deflectControlParam", deflectMaxDeg, deflectVelMaxDeg, deflectAccMaxDeg, deflectFreqResponse, deflectDampResponse, deflectDtMax (1 character string, 6 floats)

"deflectControlParam"	Record tag.
deflectMaxDeg	Maximum deflection angle (deg). This value is typically set to 35°.
deflectVelMaxDeg	Maximum deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
deflectAccMaxDeg	Maximum deflection acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
deflectFreqResponse	Undamped response frequency of deflection controller.
deflectDampResponse	Damping of deflection controller as a fraction of critical damping. This value is typically between 0.5 and 1.0.
deflectDtMax	Maximum time increment for time stepping of azimuthing propeller deflections. This parameter doesn't affect frequency domain computations with SM3DSeakeepRandom3.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9c), Azimuthing Propeller Deflection Controller Displacement Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a)

"deflectDispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"deflectDispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a ship using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9d), Azimuthing Propeller Deflection Controller Velocity Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a)

"deflectVelGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"deflectVelGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a ship using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9e), End of Azimuthing Propeller Controller Settings

"end aziPropellerDeflectControllerSettings" (2 character strings)

Record (10), Output Options for Parameters in Regular Seas

"outRaoOptions", outMotionRaoOption, outRudderRaoOption, outAziPropRaoOption, outUTubeTankRaoOption, outRollDampOption, outPositionRaoOption, outWaveKinRaoOption (8 character strings)

"outRaoOptions"	Record tag.
outMotionRaoOption	Option for writing motion RAOs: MotionRao - Ship motion RAOs are written to output. NoMotionRao - Ship motion RAOs are not written.
outRudderRaoOption	Option for writing rudder deflection RAOs: RudderRao - Rudder deflection RAOs are written. NoRudderRao - Rudder deflection RAOs are not written.
outAziPropRaoOption	Option for writing azimuthing propeller deflections: AziPropRao - Azimuthing propeller deflections are written to output. NoAziPropRao - Azimuthing propeller deflections are not written to output.
outUTubeTankRaoOption	Option for writing U-tube tank fluid displacements: UTubeTankRao - U-tube tank fluid displacements are written to output. NoUTubeTankRao - U-tube tank fluid displacements are not written to output.
outRollDampOption	Option for writing roll damping values: RollDamp - Roll damping coefficients are written. NoRollDamp - Roll damping coefficients are not written.
outPositionRaoOption	Option for writing seakeeping position RAOs: PositionRao - Seakeeping positions RAOs are written. NoPositionRao - Seakeeping positions RAOs are not written.
outWaveKinRaoOption	Option for writing wave kinematics RAOs: WaveKinRao - Wave kinematics RAOs are written. NoWaveKinRao - Wave kinematics RAOs are not written.

Record (11), Option for Output Post-Processing File with Motion and Deflection Response Amplitude Operators

"outMoDefRaoPprOption", outMoDefRaoPprOption (2 character strings)

"outMoDefRaoPprOption"	Record tag.
outMoDefRaoPprOption	Option for output of data file with motion and appendage deflections response amplitude operators for post-processing. This file is a MotionDeflectRaoDB object in .NET binary serialization format. MoDefRaoPpr - Motion and appendage deflection RAOs are written to a file in .NET binary format. NoMoDefRaoRaoPpr - Motion RAOs are not written to a file in .NET binary format.

Record (11a), Output Motion and Deflection Response Amplitude Operator File Name

This record should only be given if outMoDefRaoPprOption in Record (11) is set to MoDefRaoPpr.

"moDefRaoPprFileName", moDefRaoPprFileName (2 character strings)

"moDefRaoPprFileName"	Record tag.
moDefRaoPprFileName	Name of output file for motion and appendage deflection response amplitude operators in .NET binary format.

Record (12), Option for Output Post-Processing File with Motions and Deflections in Random Seas

"outMoDefRandomPprOption", outMoDefRandomPprOption (2 character strings)

"outMoDefRandomPprOption"	Record tag.
outMoDefRandomPprOption	Option for output of data file with RMS and zero-crossing periods for ship motions and appendage deflections. This file is a MotionDeflectRmsTzRandomDB object in .NET binary serialization format. MoDefRandomPpr - RMS and zero-crossing period values for ship motions and appendage deflections are written to a file in .NET binary format. NoMoDefRandomPpr - RMS ship motions and appendage deflections are not written to a file in .NET binary format.

Record (12a), Output Motion in Random Seas File Name

This record should only be given if outMoDefRandomPprOption in Record (12) is set to MoDefRandomPpr.

"moDefRandomPprFileName", moDefRandomPprFileName (2 character strings)

"moDefRandomPprFileName"	Record tag.
moDefRandomPprFileName	Name of output file for RMS values and zero-crossing periods in .NET binary format.

Record (13), Option for Output Post-Processing File of Response Amplitude Operators SHIPMO7 Format

This record is optional.

"outSHIPMO7PprOption", outSHIPMO7PprOption (2 character strings)

"outSHIPMO7PprOption"	Record tag.
outSHIPMO7PprOption	Option for output of data file with motion response amplitude operators in SHIPMO7 ASCII post-processing format. This file can be used for operability analysis using SHIPOP2 ([18]). SHIPMO7Ppr - Ship motion RAOs are written in SHIPMO7 ASCII post-processing format. NoSHIPMO7Ppr - Ship motion RAOs are not written in SHIPMO7 ASCII post-processing format.

Record (13a), Output Motion in Random Seas File Name

This record should only be given if outSHIPMO7PprOption in Record (13) is set to SHIPMO7Ppr.

"SHIPMO7PprFileName", SHIPMO7PprFileName (2 character strings)

"SHIPMO7PprFileName"	Record tag.
SHIPMO7PprFileName	Name of output file for in SHIPMO7 ASCII post-processing format.

Record (14), Minimum Wave Encounter Frequency

"enFreqMinMotion", enFreqMinMotion (1 character string, 1 float)

"enFreqMinMotion"	Record tag.
enFreqMinMotion	Minimum wave encounter frequency for ship motion predictions. If the combination of ship speed, heading, and wave frequency gives an encounter frequency less than this value, then the wave frequency is shifted. This variable is used to avoid large amplitude motions at very low encounter frequencies. A value of approximately $0.3\sqrt{g/L}$ is recommended.

Record (15a), Ship Speed Range in m/s

One of Records (15a) to (15f) must be given.

"speedRange", speedMin, speedMax, speedInc (1 character string, 3 floats)

"speedRange"	Record tag.
speedMin	Minimum ship speed (m/s).
speedMax	Maximum ship speed (m/s).
speedInc	Increment for ship speed (m/s).

Record (15b), Ship Speeds in m/s

One of Records (15a) to (15f) must be given.

"speeds", speeds (1 character string, array of floats)

"speeds"	Record tag.
speeds	Array of ship speeds (m/s).

Record (15c), Ship Speed Range in Knots

One of Records (15a) to (15f) must be given.

"speedKnotsRange", speedKnotsMin, speedKnotsMax, speedKnotsInc (1 character string, 3 floats)

"speedKnotsRange"	Record tag.
speedKnotsMin	Minimum ship speed (knots).
speedKnotsMax	Maximum ship speed (knots).
speedKnotsInc	Increment for ship speed (knots).

Record (15d), Ship Speeds in Knots

One of Records (15a) to (15f) must be given.

"speedsKnots", speedsKnots (1 character string, array of floats)

"speedsKnots"	Record tag.
speedsKnots	Array of ship speeds (knots).

Record (15e), Froude Number Range

One of Records (15a) to (15f) must be given.

"FroudeRange", froudeMin, froudeMax, froudeInc (1 character string, 3 floats)

"FroudeRange"	Record tag.
froudeMin	Minimum Froude number.
froudeMax	Maximum Froude number.
froudeInc	Froude number increment.

Record (15f), Ship Froude Numbers

One of Records (15a) to (15f) must be given.

"Froudes", froudes (1 character string, array of floats)

"Froudes"	Record tag.
froudes	Array of ship Froude numbers.

Record (16a), Range of Sea Directions Relative to the Ship for Computing Motion RAOs

One of Records (16a) or (16b) must be given.

"seaDirDegRange", seaDirDegMin, seaDirDegMax, seaDirDegInc (1 character string, 3 floats)

"seaDirDegRange"	Record tag.
seaDirDegMin	Minimum sea direction relative to ship (deg).
seaDirDegMax	Maximum sea direction relative to ship (deg).
seaDirDegInc	Increment sea direction relative to ship (deg).

Record (16b), Sea Directions Relative to the Ship for Computing Motion RAOs

One of Records (16a) or (16b) must be given.

"seaDirsDeg", seaDirsDeg (1 character string, array of floats)

"seaDirsDeg"	Record tag.
seaDirsDeg	Array of sea directions relative to the ship (deg) .

Record (17a), Range of Sea Directions Relative to the Ship for Seakeeping Computations in Random Seas

One of Records (17a) or (17b) can optionally be given.

"seaDirDegRangeSeakeep", seaDirDegSeakeepMin, seaDirDegSeakeepMax, seaDirDegSeakeepInc (1 character string, 3 floats)

"seaDirDegRangeSeakeep"	Record tag.
seaDirDegSeakeepMin	Minimum sea direction relative to ship (deg) for seakeeping computations (deg).
seaDirDegSeakeepMax	Maximum sea direction relative to ship for seakeeping computations (deg).
seaDirDegSeakeepInc	Increment sea direction relative to ship for seakeeping computations (deg).
Note:	Either Record (17a) or (17b) can optionally be given as input to specify sea directions for seakeeping computations. If neither record is given, then seakeeping computations are performed for sea directions specified by either Record (16a) or Record (16b).

Record (17b), Sea Directions Relative to the Ship for Seakeeping Computations in Random Seas

One of Records (17a) or (17b) can optionally be given.

"seaDirsDegSeakeep", seaDirsDegSeakeep (1 character string, array of floats)

"seaDirsDegSeakeep"	Record tag.
seaDirsDegSeakeep	Array of sea directions relative to the ship for seakeeping computations (deg) .
Note:	Either Record (17a) or (17b) can optionally be given as input to specify sea directions for seakeeping computations. If neither record is given, then seakeeping computations are performed for sea directions specified by either Record (16a) or Record (16b).

Record (18a), Range of Incident Wave Frequencies

One of Records (18a) or (18b) must be given.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc (1 character string, 3 floats)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum incident wave frequency (rad/s).
waveFreqMax	Maximum incident wave frequency (rad/s).
waveFreqInc	Increment for incident wave frequency (rad/s).

Record (18b), Incident Wave Frequencies

One of Records (18a) or (18b) must be given.

"waveFreqs", waveFreqs (1 character string, array of floats)

"waveFreqs"	Record tag.
waveFreqs	Array of increasing incident wave frequencies (rad/s).

Record (19), Wave Spectrum Option

"spectrumOption", spectrumOption (2 character strings)

"spectrumOption"	Record tag.
spectrumOption	Wave spectrum option. Options are:
	Bretschneider - Bretschneider spectrum.
	JONSWAP - JONSWAP spectrum.
	OchiHubble - Six parameter Ochi and Hubble spectrum.
	InputSpectrum - Input spectral densities.

Record (20a), Parameters for Bretschneider Spectrum

This record is required if spectrumOption is set to Bretschneider in Record (19).

"BretParam", hs, tp (1 character string, 2 floats)

"BretParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).

Record (20b), Parameters for JONSWAP Spectrum

This record is required if spectrumOption is set to JONSWAP in Record (19).

"JONSWAPParam", waveHeadingDeg, hs, tp, peakEnhance (1 character string, 3 floats)

"JONSWAPParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).
peakEnhance	Peak enhancement factor γ. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (20c), Parameters for Ochi and Hubble Six Parameter Spectrum

This record is required if spectrumOption is set to OchiHubble in Record (19).

"OchiHubbleParam", hs1, freqPeak1, spectralShape1, hs2, freqPeak2, spectralShape2 (1 character string, 6 floats)

"OchiHubbleParam"	Record tag.
hs1	Significant wave height h_{s-1} of wave system 1 (m).
freqPeak1	Peak wave frequency ω_{p-1} of wave system 1 (rad/s).
spectralShape1	Spectral shape factor λ_1 of wave system 1.
hs2	Significant wave height h_{s-2} of wave system 2 (m).
freqPeak2	Peak wave frequency ω_{p-2} of wave system 2 (rad/s).
spectralShape2	Spectral shape factor λ_2 of wave system 2.

Record (20d1), Input Spectrum Wave Frequencies

This record is required if spectrumOption in Record (19) is set to InputSpectrum.

"inputWaveFreqs", inputWaveFreqs (1 character string, array of floats)

"inputWaveFreqs"	Record tag.
inputWaveFreqs	Wave frequencies ω_I for input energy densities (rad/s).

Record (20d2), Input Spectrum Energy Densities

This record is required if spectrumOption in Record (19) is set to InputSpectrum.

"inputEnergyDensities", inputEnergyDensities (1 character string, array of floats)

"inputEnergyDensities"	Record tag.
inputEnergyDensities	Wave spectrum energy densities $S_{\omega_I}(\omega_I)$ corresponding to wave frequencies of Record (20d1).

Record (21), Directional Spreading Angle

"spreadAngleDeg", spreadAngleDeg (1 character string, 1 float)

"spreadAngleDeg"	Record tag.
spreadAngleDeg	Directional spreading angle θ_s (degrees). If short-crested seas are being modelled (non-zero spreading angle), then the sea directions specified by Record (16a) or (16b) must go from 0 to 180 degrees, with a maximum increment of 30 degrees between adjacent sea directions.

Record (22), Beginning of Steady Forward Speed Sinkage and Trim Data

Records (22) to (22b) can optionally be used to give ship sinkage and trim data.

"begin steadySinkageTrim" (1 character string with 2 words)

Record (22a), Sinkage and Trim for Ship Speed

This record is repeated once for every ship speed with sinkage and trim data, with increasing ship speeds.

"speedSinkageTrim", speedSinkageTrim, heaveSteady, pitchSteadyDeg (1 character string, 3 floats)

"speedSinkageTrim"	Record tag.
speedSinkageTrim	Speed for which sinkage and trim values are given (m/s)
heaveSteady	Heave at steady speed (m, + up).
pitchSteadyDeg	Pitch at steady speed (deg, + bow down).

Record (22b), End of Steady Sinkage and Trim Data

This record is required if Records (22) and (22a) are included.

"end steadySinkageTrim" (1 character string with 2 words)

Record (23), Beginning of Steady Forward Speed Wave Elevation Data

Records (23) to (23d) can optionally be used to give ship steady wave profile data data.

"begin steadyWaveProfile" (1 character string with 2 words)

Record (23a), Stations for Steady Wave Elevation Data

This record is required if steady wave elevation data are being given.

"stationsSteadyWaveProfile", stationsSteadyWaveProfile (1 character string, nStationSteadyWaveProfile floats)

"stationsSteadyWaveProfile"	Record tag.
stationsSteadyWaveProfile	Ship stations for steady wave elevation data.

Record (23b), Speeds in m/s for Steady Wave Elevation Data

This record is required if steady wave elevation data are being given.

"speedsSteadyWaveProfile", speedsSteadyWaveProfile (1 character string, nSpeedSteadyWaveProfile floats)

"speedsSteadyWaveProfile"	Record tag.
speedsSteadyWaveProfile	Ship speeds for steady wave elevation data (m/s).

Record (23c), Steady Wave Elevation Profile Data

This record must be given for each station with steady wave elevation data.

"stationSteadyWaveElevs", stationSteadyWave, waveElevsSteady (1 character string, 1 + nSpeedSteadyWaveProfile floats)

"stationSteadyWaveElevs"	Record tag.
stationSteadyWave	Station number for input wave elevations. This value must be consistent with values given in Record (23a).
waveElevsSteady	Wave elevations (m) at stationSteadyWave for ship speeds specified in Record (23b).

Record (23d), End of Steady Wave stationSteadyWaveProfile Data

This record is required if Record (23) and subsequent records have been entered.

"end steadyWaveProfile" (1 character string with 2 words)

Record (24), Beginning of Seakeeping Position Data

This record is optional.

"begin seakeepPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (24a) to (24g6) giving seakeeping position parameters. Record (24h) must follow at the end of all seakeeping position data.

Record (24a), Seakeeping Position Label

This record is required if a seakeeping position is being specified.

"labelPos", labelPos (2 character strings)

"labelPos"	Record tag.
labelPos	Label for seakeeping position. This can include spaces.

Record (24b), Seakeeping Position Location

This record is required if a seakeeping position is being specified.

“locationPos”, stationPos, yPos, zBlPos (1 character string, 3 floats)

“locationPos”	Record tag.
stationPos	Station for seakeeping position. Station 0 is at the fore perpendicular.
yPos	Lateral coordinate (+ port) relative to ship centreline (m).
zBlPos	Vertical coordinate (+ up) relative to ship baseline (m).

Record (24c), Option Radiation and Diffraction when Evaluating Relative Vertical Motion

This record is optional if a seakeeping position is being specified.

“relMoRadDifOption” relMoRadDifOption (2 character strings)

“relMoRadDifOption”	Record tag.
relMoRadDifOption	Option for including radiation and diffraction in relative vertical motion: NoRadDif - Wave radiation and diffraction are not considered when evaluating relative wave motion (default).

Record (24d), Option for Including the Steady Wave Due to Ship Forward Speed when Evaluating Wetness or Emergence Events

This record is optional if a seakeeping position is being specified.

"relWaveElevSteadyOption", relWaveElevSteadyOption (2 character strings)

"relWaveElevSteadyOption"	Record tag.
relWaveElevSteadyOption	Option for including the influence of the steady wave field due to ship forward speed when evaluating distance from the waterline in calm water: NoSteadyWave - The steady wave due to ship forward speed is not included (default). This option must be used if no steady wave data are provided in Records (22) to (23d). SinkageTrimOnly - The ship sinkage and trim due to ship forward speed are included when evaluated vertical position relative to the calm waterline. Sinkage and trim values specified in input Records (22) to (22b). SteadyWaveElev - The steady wave elevation is evaluated based on steady wave profile specified in Records (23) to (23d). Sinkage and trim from Records (22) to (22b) are included.

Record (24e), Option for Motion-Induced Interruptions

This record is required if a seakeeping position is being specified.

"miiOption", miiOption (2 character strings)

"miiOption"	Record tag.
miiOption	Option for motion-induced interruption computations: Mii - Motion-induced interruption computations are performed. NoMii - No motion-induced interruption computations are performed.

Record (24e1), Parameters for Motion-Induced Interruptions

This record is required if miiOption is set to mii in Record (24e).

"miiParam", tipCoLat, tipCoLong, durationMii (1 character strings, 3 floats)

"miiParam"	Record tag.
tipCoLat	Lateral tipping coefficient. A value of 0.25 is typically used for humans facing forward.
tipCoLong	Longitudinal tipping coefficient. A value of 0.17 is typically used for humans facing forward.
durationMii	Duration for computing incidence of motion-induced interruptions (s). A value of 60 s is typically used.
Note:	For sliding calculations, the user should set tipCoLat and tipCoLong equal to the static coefficient of friction.

Record (24f), Option for Motion Sickness Incidence

This record is required if a seakeeping position is being specified.

"motionSicknessOption", motionSicknessOption (2 character strings)

"motionSicknessOption"	Record tag.
motionSicknessOption	Option for motion sickness computations:
	MotionSickness - Motion sickness computations are performed.
	NoMotionSickness - No motion sickness computations are performed.

Record (24f1), Exposure Time for Motion Sickness Incidence

This record is required if MotionSicknessOption is set to MotionSickness in Record (24f).

"tDayMotionSickness", tDayMotionSickness (1 character strings, 1 float)

"tDayMotionSickness"	Record tag.
tDayMotionSickness	Exposure time at which motion sickness incidence is computed (days).

Record (24g), Option for Slamming, Deck Wetness, or Emergence Computations

This record is required if a seakeeping position is being specified.

“slamWetEmergeOption”, slamWetEmergeOption (2 character strings)

“slamWetEmergeOption”	Record tag.
slamWetEmergeOption	Option for slamming, deck wetness, or emergence computations: NoSlamWetEmerge - No slamming, deck wetness, or emergence computations are performed. SlamPressureCoWidth - Slamming calculations are performed using an input slamming form factor and effective pressure width specified in Record (24g2). SlamWedge - Slamming calculations are performed using wedge dimensions given in Record (24g3). SlamOffsets - Slamming calculations are performed using offsets given in Records (24g4), (24g5), and (24g6). WetnessEmerge - Incidence of wetness or emergence calculations are performed, depending on whether the position is above or below the waterline.

Record (24g1), Duration and Exceedence Probability for Slamming, Wetness, or Emergence Statistics

This record is required if slamWetEmergeOption in Record (21f) is set to SlamPressureCoWidth, SlamWedge, SlamOffsets, or WetnessEmerge.

“durationPExceed”, durationHours, pExceed (1 character string, 2 floats)

“durationPExceed”	Record tag.
durationHours	Duration for slamming, wetness, or emergence statistics (hours).
pExceed	Exceedence probability for slamming, wetness, or emergence statistics.

Record (24g2), Slamming Pressure Coefficient and Effective Pressure Width

This record is required if slamWetEmergeOption in Record (24g) is set to SlamPressureCoWidth.

"slamPressureCoWidth", slamPressureCo, slamForceWidth (1 character string, 2 floats)

"slamPressureCoWidth"	Record tag.
slamPressureCo	Slamming pressure coefficient.
slamForceWidth	Effective slamming force width (m).

Record (24g3), Wedge Geometry for Slamming Calculations

This record is required if slamWetEmergeOption in Record (24g) is set to SlamWedge.

"slamWedge", deadRiseDeg, slamForceHeight (1 character string, 2 floats)

"slamWedge"	Record tag.
deadRiseDeg	Hull deadrise angle at keel (degrees). This value must be greater than 0 degrees. For deadrise angles less than 5 degrees, this approach can be inaccurate, and is recommended that either the slamForm or slamOffsets option be used instead for slamWetEmergeOption in Record (24g).
slamForceHeight	Height above the baseline at which slamming pressure goes to zero (typically taken as $0.1T_x$, where T_x is the sectional draft of the keel).

Record (24g4), Elevation Above Baseline for Zero Slamming Pressure

This record is required if slamWetEmergeOption in Record (24g) is set to SlamOffsets.

"zBlZeroSlamPres", zBlZeroSlamPres (1 character string, 1 floats)

"zBlZeroSlamPres"	Record tag.
zBlZeroSlamPres	Elevation above baseline at which slamming pressure goes to zero (m). This value is typically assumed to be at a height of $0.1T_x$ above the baseline, where T_x is sectional draft.

Record (24g5), Y Offsets for Performing Slamming Calculations

This record is required if slamWetEmergeOption in Record (24g) is set to SlamOffsets.

"yOffsetsSlam", yOffsetsSlam (1 character string, array of floats)

"yOffsetsSlam"	Record tag.
yOffsetsSlam	Horizontal offsets for points going from keel to at least zBlZeroSlamPres (Record (24g4)) above the baseline (m).

Record (24g6), Z Offsets for Performing Slamming Calculations

This record is required if slamWetEmergeOption in Record (24g) is set to SlamOffsets.

"zBlOffsetsSlam", zBlOffsetsSlam (1 character string, array of floats)

"zBlOffsetsSlam"	Record tag.
zBlOffsetsSlam	Vertical offsets for points going from keel to at least zBlZeroSlamPres (Record (24g4)) above the baseline (m).

Record (24h), End of Seakeeping Position Data

This record is required if Record (24) is present.

"end seakeepPositions" (1 character string with 2 words)

Record (25), Beginning of Wave Kinematics Position Data

This record is optional.

"begin waveKinPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (25a) to (25c) giving wave kinematics position parameters. Record (25d) must follow at the end of wave kinematics position data.

Record (25a), Wave Kinematics Position Label

This record is required if a wave kinematic position is being specified.

"labelWaveKin", labelWaveKin (2 character strings)

"labelWaveKin"	Record tag.
labelWaveKin	Label for wave kinematic position. This can include spaces.

Record (25b1), Wave Kinematics Position Station and Elevation Relative to Baseline

One of Record (25b1), (25b2), or (25b3) is required if a wave kinematics position is being specified.

"stationYZBlWaveKin", stationWaveKin, yWaveKin, zBlWaveKin (1 character string, 3 floats)

"stationYZBlWaveKin"	Record tag.
stationWaveKin	Station for wave kinematic position. Station 0 is at the fore perpendicular.
yWaveKin	Lateral coordinate (+ port) relative to ship centreline (m).
zBlWaveKin	Vertical coordinate (+ up) relative to ship baseline (m). If this position is above the calm waterline for the trimmed ship, then it is moved to the calm waterline.

Record (25b2), Wave Kinematics Position Station and Elevation Relative to Calm Waterline

One of Record (25b1), (25b2), or (25b3) is required if a wave kinematics position is being specified.

“stationYZWlWaveKin”, stationWaveKin, yWaveKin, zWlWaveKin (1 character string, 3 floats)

“stationYZWlWaveKin”	Record tag.
stationWaveKin	Station for wave kinematic position. Station 0 is at the fore perpendicular.
yWaveKin	Lateral coordinate (+ port) relative to ship centreline (m).
zWlWaveKin	Vertical coordinate (+ up) relative to the calm waterline (m).

Record (25b3), Wave Kinematics Position X Coordinate and Elevation Relative to Calm Waterline

One of Record (25b1), (25b2), or (25b3) is required if a wave kinematics position is being specified.

“xYZWlWaveKin”, xWaveKin, yWaveKin, zWlWaveKin (1 character string, 3 floats)

“xYZWlWaveKin”	Record tag.
xWaveKin	x coordinate (+ forward, relative to ship CG) for wave kinematic position (m).
yWaveKin	Lateral coordinate (+ port) relative to ship centreline (m).
zWlWaveKin	Vertical coordinate (+ up) relative to the calm waterline (m).

Record (25c), Option for Including Radiation and Diffraction in Wave Kinematics

This record is optional if a wave kinematics position is being specified.

"waveKinRadDif", waveKinRadDifOption (2 character strings)

"waveKinRadDif"	Record tag.
waveKinRadDifOption	Option for including radiation and diffraction in wave kinematics:
	NoRadDif - Wave radiation and diffraction are not considered when evaluating wave kinematics (default).

Record (25d), End of Wave Kinematics Position Data

This record is required if Record (25) is present

"end waveKinPositions" (1 character string with 2 words)

Record (26), Plot Output Option

"plotOutOption", plotOutOption (2 character strings)

"plotOutOption"	Record tag.
plotOutOption	Option for making plots:
	NoPlots - No plots are produced.
	ScreenFile - Plots are both plotted on the screen and to a file.
	Screen - Plots are only plotted on the screen.
	File - Plots are only written to a file.

Record (27), Beginning of Ship Motion RAO Plot Data

This record is optional.

"begin motionRaoPlots" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (27a) to (27h) giving plot parameters. Record (27i) must follow at the end of plot parameter data.

Record (27a), Motion RAO Plot Image File Name

This record is required if a plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (27b), Motion RAO Plot Image Format

This record is optional if a plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (27c), Motion RAO Plot Image Size

This record is optional if a plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 200 mm)

Record (27d1), Motion RAO Plot Speed in m/s

One of Records (27d1), (27d2), or (27d3) is required for each plot being specified.

"speed", speed (1 character string, 1 float)

"speed"	Record tag.
speed	Ship speed (m/s) for plotted RAOs. This speed should correspond to a speed specified for computations in one of Records (15a) to (15f).

Record (27d2), Motion RAO Plot Speed in Knots

One of Records (27d1), (27d2), or (27d3) is required for each plot being specified.

"speedKnots", speedKnots (1 character string, 1 float)

"speedKnots"	Record tag.
speedKnots	Ship speed (knots) for plotted RAOs. This speed must correspond to a speed specified for computations in one of Records (15a) to (15f).

Record (27d3), Motion RAO Plot Froude Number

One of Records (27d1), (27d2), or (27d3) is required for each plot being specified.

"Froude", Froude (1 character string, 1 float)

"Froude"	Record tag.
Froude	Ship forward speed Froude number for plotted RAOs. This speed should correspond to a speed specified for computations in one of Records (15a) to (15f).

Record (27e), Motion RAO Plot Sea Direction

This record is required for each plot being specified.

"seaDirDeg", seaDirDeg (1 character string, 1 float)

"seaDirDeg"	Record tag.
seaDirDeg	Sea direction (deg) relative to ship for plotted RAOs. This sea direction must correspond to a sea direction specified for computations Record (16a) or (16b).

Record (27f), Option for Longitudinal and/or Lateral Modes

This record is optional if a plot is being specified.

“longLatOption”, longLatOption (2 character strings)

“longLatOption”	Record tag.
longLatOption	Option for plotting modes.
	LongLat - Longitudinal and lateral and modes will be shown with longitudinal modes in the left column and lateral modes in the right column (default).
	Long - Longitudinal modes will be shown in a single column.
	Lat - Lateral modes will be shown in a single column.

Record (27g), Column Options for Longitudinal Modes

This record is optional if a plot is being specified.

“longColumns”, surgeColumn, heaveColumn, pitchColumn (3 character strings)

“longColumns”	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
surgeColumn	Column of surge graph.
heaveColumn	Column of heave graph.
pitchColumn	Column of pitch graph.
Note:	The values in this record will override values set based on longLatOption in Record (21f).

Record (27h), Column Options for Lateral Modes

This record is optional if a plot is being specified.

"latColumns", swayColumn, rollColumn, yawColumn, deflectColumn (5 character strings)

"latColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
swayColumn	Column of sway graph.
rollColumn	Column of roll graph.
yawColumn	Column of yaw graph.
deflectColumn	Column of graph with rudder and/or azimuthing propeller deflection angle RAOs.
Note:	The values in this record will override values set based on longLatOption in Record (27f).

Record (27i), End of Ship Motion RAO Plot Data

"end motionRaoPlots" (1 character string with 2 words)

Record (28), Beginning of Ship Motion in Random Seas Plot Data

This record is optional.

"begin motionRandomPlots" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (28a) to (28h) giving plot parameters. Record (28i) must follow at the end of plot parameter data.

Record (28a), Motion in Random Seas Plot Image File Name

This record is required if a plot is being specified.

"imageFileName", imageFileName (2 character strings)

"imageFileName"	Record tag.
imageFileName	Name of output plot file.

Record (28b), Motion in Random Seas Plot Image Format

This record is optional if a plot is being specified.

"imageFormat", imageFormat (2 character strings)

"imageFormat"	Record tag.
imageFormat	Plot image format. Available formats are png (default) and jpg.

Record (28c), Motion in Random Seas Plot Image Size

This record is optional if a plot is being specified.

"imageSize", widthmm, heightmm (1 character string, 2 floats)

"imageSize"	Record tag.
widthmm	Plot width (mm). (Default 150 mm)
heightmm	Plot height (mm). (Default 200 mm)

Record (28d1), Motion in Random Seas Speed in m/s

One of Records (28d1), (28d2), or (28d3) is required for each plot being specified.

"speed", speed (1 character string, 1 float)

"speed"	Record tag.
speed	Ship speed (m/s) for plotted motions. This speed must correspond to a speed specified for computations in one of Records (15a) to (15f).

Record (28d2), Motion in Random Seas Speed in Knots

One of Records (28d1), (28d2), or (28d3) is required for each plot being specified.

"speedKnots", speedKnots (1 character string, 1 float)

"speedKnots"	Record tag.
speedKnots	Ship speed (knots) for plotted motions. This speed must correspond to a speed specified for computations in one of Records (15a) to (15f).

Record (28d3), Motion in Random Seas Froude Number

One of Records (28d1), (28d2), or (28d3) is required for each plot being specified.

"Froude", Froude (1 character string, 1 float)

"Froude"	Record tag.
Froude	Ship forward speed Froude number for plotted motions. This speed must correspond to a speed specified for computations in one of Records (15a) to (15f).

Record (28e), Motion in Random Seas RMS or Zero-Crossing Period Option

This record is optional if a plot is being specified.

"rmsTzOption", rmsTzOption (2 character strings)

"rmsTzOption"	Record tag.
rmsTzOption	Option for of RMS motions or zero-crossing periods: Rms - RMS motions will be plotted (default). Tz - Zero-crossing periods will be plotted.

Record (28f), Option for Longitudinal and/or Lateral Modes

This record is optional if a plot is being specified.

"longLatOption", longLatOption (2 character strings)

"longLatOption"	Record tag.
longLatOption	Option for plotting modes:
	LongLat - Longitudinal and lateral and modes will be shown with longitudinal modes in the left column and lateral modes in the right column (default).
	Long - Longitudinal modes will be shown in a single column.
	Lat - Lateral modes will be shown in a single column.

Record (28g), Column Options for Longitudinal Modes

This record is optional if a plot is being specified.

"longColumns", surgeColumn, heaveColumn, pitchColumn (3 character strings)

"longColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
surgeColumn	Column of surge graph.
heaveColumn	Column of heave graph.
pitchColumn	Column of pitch graph.
Note:	The values in this record will override values set based on longLatOption in Record (28f).

Record (28h), Column Options for Lateral Modes

This record is optional if a plot is being specified.

"latColumns", swayColumn, rollColumn, yawColumn, deflectColumn (5 character strings)

"latColumns"	Record tag.
	Values for each of the following can be one of:
	Left
	Right
	Hide
swayColumn	Column of sway graph.
rollColumn	Column of roll graph.
yawColumn	Column of yaw graph.
deflectColumn	Column of graph with rudder and/or azimuthing propeller deflection angles.
Note:	The values in this record will override values set based on longLatOption in Record (28f).

Record (28i), End of Ship Motion in Random Seas Plot Data

"end motionRandomPlots" (1 character string with 2 words)

Record (29), End Record

"end SM3DSeakeepRandom3"(1 character string with 2 words)

D.2 Sample Input File for SM3DSeakeepRandom3

```
begin SM3DSeakeepRandom3
label Generic frigate
shipDBFileName genFrigShipForMotionDB.bin
lengthData 120.000 20.000
loadCondition 1025.000 4.200 0.000 6.000 0.000
outRaoOptions NoMotionRao NoRudderRao NoAziPropRao NoUTubeTankRao  !
              NoRollDamp NoPositionRao NoWaveKinRao
outMoDefRaoPprOption MoDefRaoPpr
moDefRaoPprFileName genFrigSeakeepRandomMoDefRaoDB.bin
outMoDefRandomPprOption MoDefRandomPpr
moDefRandomPprFileName genFrigSeakeepRandomMoDefRandomDB.bin
enFreqMinMotion 0.1
speedKnotsRange 0 30 10
seaDirDegRange 0 180 15
waveFreqRange 0.2 2 0.05
spectrumOption Bretschneider
BretParam 3.25 9.7
spreadAngleDeg 0
begin seakeepPositions
labelPos Seakeeping position
    locationPos 3 2 12
    relMoRadDifOption NoRadDif
    relWaveElevSteadyOption NoSteadyWave
    miiOption Mii
    miiParam 0.25 0.17 60
    motionSicknessOption MotionSickness
    tDayMotionSickness 0.25
    slamWetEmergeOption WetnessEmerge
    durationPExceed 1 0.01
end seakeepPositions
plotOutOption NoPlots
end SM3DSeakeepRandom3
```

D.3 Sample Output File for SM3DSeakeepRandom3 (Motions Only Given for One Ship Speed)

```
Program SM3DSeakeepRandom3
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-10-11 9:07:39 AM
Run label:
Generic frigate

**** ECHO OF USER INPUT ****

Input ship for motion database file name:
genFrigShipForMotionDB.bin
Label   : Generic frigate
Created : November-09-11 8:19:55 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.ShipForMotionDB

Ship Length Data
Length between perpendiculars :   120.000 m
Station of aft perpendicular  :    20.000

Ship Loading Condition
Water density : 1025.000 kg/m3
Draft of baseline at midships       :     4.200 m
Trim of baseline by stern           :     0.000 m
Height of CG above baseline, KG     :     6.000 m
Correction to metacentric height GM :     0.000 m

Options for Output of Response Amplitude Operators in Long-crested Seas
Output motion RAO option              : NoMotionRao
Output rudder deflection              : NoRudderRao
Output azimuthing propeller deflection : NoAziPropRao
Output U-tube tank fluid angle        : NoUTubeTankRao
Output roll damping option            : NoRollDamp
Output seakeeping position option     : NoPositionRao
Output wave kinematics option         : NoWaveKinRao

Output motion and deflection RAO post-processing file option : MoDefRaoPpr
File name with motion RAOs for post-processing :
genFrigSeakeepRandomMoDefRaoDB.bin

Output RMS motion post-processing file option : MoDefRandomPpr
File name with RMS motions for post-processing :
genFrigSeakeepRandomMoDefRandomDB.bin

Minimum wave encounter frequency for predicting ship motions : 0.100 rad/s

Speed range
Minimum   :    0.000 knots
```

```
Maximum   :   30.000 knots
Increment :   10.000 knots

Sea direction range
Minimum   :    0.000 deg
Maximum   :  180.000 deg
Increment :   15.000 deg

Incident wave frequency range
Minimum   :    0.200 rad/s
Maximum   :    2.000 rad/s
Increment :    0.050 rad/s

Seaway
Spectrum option :
Bretschneider spectrum parameters
Significant wave height :     3.250 m
Peak wave period        :     9.700 s
Wave spreading angle    : 0.0 deg

Seakeeping Positions

Label               : Seakeeping position
Station             :     3.000
Lateral offset y    :     2.000 m (+ port)
Vertical offset zBl :    12.000 m (+ up, relative to baseline)
Option for including radiation and diffraction for relative motion : NoRadDif
                                                                     (input)
Option for including steady wave due to ship forward speed : NoSteadyWave (input)
Option for motion-induced interruption computations : Mii
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Duration for MII incidence       :      60.0 s
Option for motion sickness computations : MotionSickness
Parameters for motion sickness
Exposure time :     0.250 days
Option for slamming, wetness, or emergence computations : WetnessEmerge
Parameters for slamming, wetness or emergence statistics
Duration              :     1.000 hours
Exceedence probability :  0.010000

Output plot option : NoPlots

**** SHIP LOADING CONDITION ****

Load Condition Properties for Trimmed Ship

Summary of hydrostatic properties
Number of panels on port side       :          613
Total number of panels              :         1226
```

```
Length between perpendiculars        :      120.000 m
Draft of baseline at midships        :        4.200 m
Trim of baseline by stern            :        0.000 m
Beam based on maximum y value        :       14.111 m
Volume                               :     3622.358 m3
Water density                        :     1025.000 kg/m3
Mass                                 : 3712916.723463 kg
Distance from FP to X origin (m)     :       61.750 m
(Origin located at LCG)
Station of X origin                  :       10.292
Center of buoyancy wrt waterline     :       -1.614 m
Wetted surface area                  :     1753.438 m2
Waterplane area                      :     1344.310 m2
X value of center of floatation      :       -5.022 m
Integral of waterplane area*X**2     :  1234204.219 m4
Integral of waterplane area*Y**2     :    17543.814 m4
KG, height of CG above baseline      :        6.000 m
Height of CG above waterline         :        1.800 m
Metacentric height from hydrostatics :        1.430 m

Inertial Properties

Inertia matrix, units of kg, kg*m, and kg*m2
   3712916.7          0.0          0.0          0.0          0.0          0.0
         0.0    3712916.7          0.0          0.0          0.0          0.0
         0.0          0.0    3712916.7          0.0          0.0          0.0
         0.0          0.0          0.0   85545601.3          0.0          0.0
         0.0          0.0          0.0          0.0 3341625051.1          0.0
         0.0          0.0          0.0          0.0          0.0 3341625051.1

Roll radius of gyration  :     4.800 m
Pitch radius of gyration :    30.000 m
Yaw radius of gyration   :    30.000 m

Roll Metacentric Height Properities

)Roll metacentric height from hull hydrostatics :     1.430 m
Correction due to sloshing tanks                :     0.000 m
Input correction to roll metacentric height     :     0.000 m
Corrected metacentric height                    :     1.430 m


Roll Properties at Zero Forward Speed

Roll added mass                        : 19548240.530169 kg*m**2
Nondimensional roll added mass A44/I44 :     0.229
Natural roll frequency                 :     0.704 rad/s
Natural roll period                    :     8.928 s


**** SHIP AUTOPILOT SETTINGS ****
```

```
Rudder Autopilots for Ship

Autopilot for ship with nominally steady speed and heading
Key   : Rudder
Label : Rudder
Maximum deflection   :    35.000 deg
Maximum velocity     :     3.000 deg/s
Maximum acceleration :   Not set deg/s2
Response frequency   :     3.000 rad/s
Response damping     :     0.850 rad/s (fraction of critical)
Maximum time step    :     0.100 s
Autopilot gains
Displacement gains have units of deg/m and deg/deg
Velocity gains have units of deg/(m/s) and deg/(deg/s)
Yaw gains given relative to earth-fixed axes (+yaw is clockwise)
                        Surge     Sway    Heave     Roll    Pitch      Yaw
Displacement gains :    0.000    0.000    0.000    0.000    0.000   -4.000
Velocity gains     :    0.000    0.000    0.000    0.000    0.000   -8.000


**** SEAKEEPING POSITION TRIM CONDITIONS ****

Label           : Seakeeping position
Station         :     3.000
x wrt ship CG   :    43.750 m
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Time of operation                :    60.000 s
Parameters motion sickness
Time for motion sickness               :     0.250 days


**** WAVE SPECTRUM ****

Bretschneider spectrum
Significant wave height :     3.250 m
Peak wave period        :     9.700 m
Long-crested seaway

Significant wave height based on point wave spectrum area :     3.228 m

Wave frequency       Spectral density
 (rad/s)                m2/(rad/s)
       0.200            0.000
       0.250            0.000
```

0.300	0.000
0.350	0.000
0.400	0.010
0.450	0.147
0.500	0.549
0.550	1.040
0.600	1.365
0.650	1.457
0.700	1.380
0.750	1.219
0.800	1.034
0.850	0.857
0.900	0.702
0.950	0.572
1.000	0.465
1.050	0.379
1.100	0.310
1.150	0.254
1.200	0.210
1.250	0.174
1.300	0.145
1.350	0.121
1.400	0.102
1.450	0.086
1.500	0.073
1.550	0.062
1.600	0.053
1.650	0.046
1.700	0.040
1.750	0.035
1.800	0.030
1.850	0.026
1.900	0.023
1.950	0.020
2.000	0.018

**** Motions at Ship CG in a Random Seaway ****

Bretschneider spectrum
Significant wave height : 3.250 m
Peak wave period : 9.700 m
Long-crested seaway

Ship speed : 10.300 m/s (20.000 knots, Froude number 0.300)
Sea direction (to) is relative to ship speed.
180 degrees for head seas, 90 degrees for seas from port
RMS Displacements and Zero-crossing Periods

Sea direction	Surge		Sway		Heave		Roll		Pitch		Yaw	
(deg)	(m)	(s)	(m)	(s)	(m)	(s)	(deg)	(s)	(deg)	(s)	(deg)	(s)
0.0	2.84	38.5	0.00	57.9	0.22	26.5	0.00	26.8	0.62	25.1	0.00	46.0
15.0	2.30	33.4	0.85	43.5	0.24	25.7	0.98	25.5	0.61	24.6	0.66	33.3
30.0	1.63	27.3	1.23	35.6	0.27	23.2	2.27	23.8	0.62	23.1	1.27	27.4
45.0	1.06	22.8	0.93	24.8	0.33	19.2	4.27	19.3	0.59	19.1	1.71	20.2
60.0	0.48	15.1	0.41	15.4	0.46	15.0	7.78	13.8	0.53	14.4	1.67	13.9
75.0	0.26	10.3	0.51	10.9	0.71	10.7	9.44	9.7	0.68	8.9	0.84	9.9
90.0	0.01	5.8	0.61	8.3	0.81	7.7	4.40	8.9	0.03	5.3	0.11	8.4
105.0	0.11	7.8	0.48	7.5	0.83	6.6	1.98	8.1	0.76	5.6	0.33	5.8
120.0	0.14	7.6	0.32	7.2	0.76	6.3	1.28	6.7	1.06	5.7	0.33	5.9
135.0	0.13	7.4	0.19	7.1	0.67	6.2	0.96	6.3	1.13	5.7	0.25	6.0
150.0	0.12	7.3	0.11	6.9	0.60	6.1	0.63	6.1	1.12	5.7	0.16	5.9
165.0	0.11	7.2	0.05	6.9	0.56	6.0	0.32	6.1	1.08	5.7	0.07	5.9
180.0	0.11	7.1	0.00	6.8	0.54	6.0	0.00	8.2	1.07	5.7	0.00	6.0

Rudder RMS Deflections and Zero-crossing Periods
Rudder keys and labels

Key	Label
Rudder	Rudder

Sea direction	Rudder Deflection	Tz
	(deg)	(s)
0.0	0.00	45.1

```
     15.0        2.83   32.7
     30.0        5.60   27.0
     45.0        8.00   20.0
     60.0        8.92   13.8
     75.0        5.27    9.6
     90.0        0.78    7.0
    105.0        2.91    5.2
    120.0        2.90    5.5
    135.0        2.18    5.5
    150.0        1.38    5.5
    165.0        0.66    5.5
    180.0        0.00    5.4


Seakeeping at Position on Ship

Label           : Seakeeping position
Station         :     3.000
x wrt ship CG   :    43.750 m
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Time of operation                :    60.000 s
Parameters motion sickness
Time for motion sickness               :     0.250 days
RMS Motions at Seakeeping Position

Position label : Seakeeping position

      Sea   *** Longitudinal ***        *** Lateral ***       *** Vertical *** ** Relative Vertical **
 direction      Disp     Tz     Acc      Disp     Tz     Acc      Disp     Tz     Acc       Disp     Tz     Vel
     (deg)       (m)    (s)     (g)       (m)    (s)     (g)       (m)    (s)     (g)        (m)    (s)   (m/s)
```

0.0	2.785	38.8	0.009	0.000	59.1	0.000	0.546	25.7	0.009	0.692	17.3	0.251
15.0	2.263	33.6	0.009	0.936	39.1	0.003	0.516	25.1	0.008	0.669	18.2	0.231
30.0	1.605	27.4	0.010	1.437	30.9	0.007	0.497	23.0	0.006	0.617	20.5	0.190
45.0	1.044	23.0	0.009	1.378	21.2	0.013	0.470	19.1	0.005	0.595	20.7	0.181
60.0	0.451	15.2	0.008	0.913	14.3	0.018	0.623	14.6	0.012	0.785	13.8	0.356
75.0	0.201	10.8	0.007	0.653	9.2	0.032	1.198	9.6	0.056	0.689	8.4	0.517
90.0	0.008	6.4	0.001	0.803	7.7	0.060	0.929	7.9	0.070	0.323	5.3	0.379
105.0	0.073	7.0	0.008	0.647	7.3	0.056	1.130	6.2	0.132	0.819	4.5	1.131
120.0	0.087	6.6	0.010	0.442	7.1	0.040	1.292	5.9	0.160	1.221	4.7	1.645
135.0	0.083	6.2	0.010	0.272	7.0	0.026	1.313	5.9	0.164	1.395	4.6	1.892
150.0	0.077	5.9	0.010	0.151	6.8	0.015	1.277	5.8	0.160	1.462	4.5	2.019
165.0	0.072	5.7	0.010	0.067	6.8	0.007	1.234	5.8	0.155	1.466	4.5	2.067
180.0	0.071	5.6	0.010	0.000	7.6	0.000	1.225	5.8	0.155	1.470	4.4	2.087

Forces Relative to Local Axes and Motion-Induced Interruptions

Position label : Seakeeping position

MIIs given as rate for following duration : 60.0 s
Lateral tipping coefficient   :   0.250
Longitudinal tipping coefficient :   0.170

Sea direction	***** Lateral *****			***** Longitudinal *****			Total
	Force estimator		MIIs	Force estimator		MIIs	MIIs
	RMS (g)	Tz (s)		RMS (g)	Tz (s)		
0.0	0.000	25.7	0.0	0.003	7.8	0.0	0.0
15.0	0.017	22.3	0.0	0.003	8.0	0.0	0.0
30.0	0.039	22.7	0.0	0.002	10.4	0.0	0.0
45.0	0.072	19.2	0.0	0.002	19.2	0.0	0.0
60.0	0.134	13.7	1.5	0.002	13.7	0.0	1.5
75.0	0.185	9.5	5.1	0.007	8.0	0.0	5.1
90.0	0.121	7.4	2.0	0.001	4.3	0.0	2.0
105.0	0.079	6.2	0.3	0.017	4.6	0.0	0.3
120.0	0.051	6.0	0.0	0.024	4.9	0.0	0.1
135.0	0.032	5.6	0.0	0.026	5.0	0.1	0.1

150.0	0.019	5.1	0.0	0.026	5.0	0.1	0.1
165.0	0.009	4.8	0.0	0.026	4.9	0.0	0.0
180.0	0.000	7.0	0.0	0.026	4.9	0.0	0.0

Motion Sickness Incidence at Seakeeping Position

Position label : Seakeeping position

Sea	*** Vertical Motion ***		*** Max Sickness ***		*** Sickness at Time ***
direction	RMS acc	Tz	Max MSI	t(Max MSI)	MSI(t=0.25days)
(deg)	(g)	(s)	(%)	(days)	(%)
0.0	0.009	25.7	0.0	0.69	0.0
15.0	0.008	25.1	0.0	0.69	0.0
30.0	0.006	23.0	0.0	0.69	0.0
45.0	0.005	19.1	0.0	0.69	0.0
60.0	0.012	14.6	0.0	0.68	0.0
75.0	0.056	9.6	14.9	0.56	13.2
90.0	0.070	7.9	25.2	0.51	23.8
105.0	0.132	6.2	49.0	0.37	48.5
120.0	0.160	5.9	55.9	0.33	55.6
135.0	0.164	5.9	56.7	0.33	56.5
150.0	0.160	5.8	55.8	0.33	55.6
165.0	0.155	5.8	54.7	0.34	54.4
180.0	0.155	5.8	54.5	0.34	54.2

Wetness Calculations for Position Above Waterline

Wetness probability is given as probability per wave encounter.

Position label : Seakeeping position

Elevation relative to calm waterline : 7.800 m

Sea direction	Relative vertical motion			*** Wetness ***	
	RMS disp	Tz	RMS vel	P(wet)	Rate
(deg)	(m)	(s)	(m/s)	(per enc)	(/hour)
0.0	0.692	17.3	0.251	0.000000	0.000

15.0	0.669	18.2	0.231	0.000000	0.000
30.0	0.617	20.5	0.190	0.000000	0.000
45.0	0.595	20.7	0.181	0.000000	0.000
60.0	0.785	13.8	0.356	0.000000	0.000
75.0	0.689	8.4	0.517	0.000000	0.000
90.0	0.323	5.3	0.379	0.000000	0.000
105.0	0.819	4.5	1.131	0.000000	0.000
120.0	1.221	4.7	1.645	0.000000	0.000
135.0	1.395	4.6	1.892	0.000000	0.000
150.0	1.462	4.5	2.019	0.000001	0.001
165.0	1.466	4.5	2.067	0.000001	0.001
180.0	1.470	4.4	2.087	0.000001	0.001

Annex E: Files for Motions in an Earth-Fixed Seaway with SM3DSeakeepSeaway3

E.1 Format of Input File for SM3DSeakeepSeaway3

Record (1), Beginning Record

"begin SM3DSeakeepSeaway3" (1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

noteText (character string)

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"end note" (1 character string with 2 words)

Record (4), Input Ship Database File Name

"shipDBFileName", shipDBFileName (2 character strings)

"shipDBFileName"	Record tag.
shipDBFileName	Name of input ship database file (ShipForMotionDB object) in .NET binary serialization format. This file must have been created using program SM3DBuildShip3.

Record (5), Length Data

"lengthData", lpp, stationAP (1 character string, 2 floats)

"lengthData"	Record tag.
lpp	Ship length between perpendiculars (m).
stationAP	Station number of the aft perpendicular. This value is typically 20.0
Note:	The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 m for length, and 0.001 for the station of the aft perpendicular. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (6), Ship Loading Condition

"loadCondition", waterDensity, draftBlMid, trimBlStern, shipKG, correctionGM (1 character string, 5 floats)

"loadCondition" Record tag.

waterDensity Water density (kg/m^3).

draftBlMid Draft of baseline at midships (m).

trimBlStern Trim of baseline by stern (m).

shipKG Height of centre of gravity above baseline (m).

correctionGM Correction to metacentric height (m).

Note: The values in this record must agree with the values used for the ship database file specified in Record (4). Values are considered to be in agreement when they are within a tolerance of 0.001 kg/m^3 for density, and 0.001 m for draft, trim, height of CG, and metacentric height. The output file from SM3DBuildShip3 gives the values of the above parameters.

Record (7), Beginning of Rudder Autopilot Settings.

Records (7) to (7e) are optional.

"begin rudderAutopilotSettings" (2 character strings)

Note: Records (7) to (7e) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of (4). Within Records (7) to (7e), Records (7a) to (7d) can be repeated an arbitrary number of times to set rudder autopilot parameters as required.

Record (7a), Rudder Key for Autopilot Settings

This Record must follow Record (7) if autopilot settings are being given as input.

"keyRudder" keyRudder (2 character strings)

"keyRudder" Record tag.

keyRudder Key of rudder for which autopilot settings are being specified. If the rudder key is set to "All", then the input autopilot settings are applied to all rudders.

Record (7b), Rudder Autopilot Control Parameters

This record can optionally be entered if an autopilot key has been specified using Record (7a).

"controlParam", deflectMaxDeg, velMaxDeg, accMaxDeg, freqResponse, dampResponse, dtMax (1 character string, 6 floats)

"controlParam"	Record tag.
deflectMaxDeg	Maximum rudder deflection angle (deg). This value is typically set to 35°.
velMaxDeg	Maximum rudder deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
accMaxDeg	Maximum rudder acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
freqResponse	Undamped response frequency of rudder autopilot.
dampResponse	Damping of rudder autopilot as a fraction of critical damping. This value is typically between 0.5 and 1.0
dtMax	Maximum time increment for time stepping of rudder motions. This parameter doesn't affect frequency domain computations with SM3DSeakeepSeaway.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7c), Rudder Autopilot Displacement Gains

This record can optionally be entered if an autopilot key has been specified using Record (7a).

“dispGains”, surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

“dispGains”	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless rudder roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7d), Rudder Velocity Gains.

This record can optionally be entered if an autopilot key has been specified using Record (7a)

"velGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"velGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless rudder stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a typical ship with a downward oriented rudder, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (7a), then the original values for the given ship rudder autopilot are used.

Record (7e), End of Rudder Autopilot Settings

"end rudderAutopilotSettings" (2 character strings)

Record (8), Beginning of Azimuthing Propeller Force Slopes

Records (8) to (8c) are required if the ship has azimuthing propellers.

"begin aziPropellerForceSlopes" (2 character strings)

Record (8a), Key of Azimuthing Propeller for Force Slopes

Records (8a) to (8b) are required for each azimuthing propeller.

"keyAziPropeller" keyAziPropeller (2 character strings)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller.

Record (8b), Ship Speed and Azimuthing Propeller Force Slopes

This record can be repeated an arbitrary number of times after Record (8a). Note that ship speeds must be in ascending order.

"aziPropellerForceSlopes", speedAziPropeller, swayForceDeflectSlopeDeg, heaveForceDeflectSlopeDeg (1 character string, 3 floats)

"aziPropellerForceSlopes"	Record tag.
speedAziPropeller	Ship speed (m/s) corresponding to force slopes.
swayForceDeflectSlopeDeg	Sway force deflection slope $\partial F_2/\partial\delta$ (N/deg) for azimuthing propeller. For a typical downward pointing azimuthing propeller (dihedral angle of $-90°$), this value will be negative.
heaveForceDeflectSlopeDeg	Heave force deflection slope $\partial F_3/\partial\delta$ (N/deg) for azimuthing propeller. For a typical downward pointing azimuthing propeller (dihedral angle of $-90°$), this value will be approximately 0.0.
Note:	The above required input terms are given in the output from SM3DBuildShip3.

Record (8c), End of Azimuthing Propeller Force Slopes

This record is required if the ship has azimuthing propellers.

"end aziPropellerForceSlopes" (2 character strings)

Record (9), Beginning of Azimuthing Propeller Deflection Controller Settings

Records (9) to (9e) are optional.

"begin aziPropellerDeflectControllerSettings" (2 character strings)

Note: Records (9) to (9e) are optional and can be used to supersede autopilot settings for a ship defined by SM3DBuildShip3 given in the file of Record (4). Within Records (9) to (9e), Records (9a) to (9d) can be repeated an arbitrary number of times to set azimuthing propeller controller parameters as required.

Record (9a), Azimuthing Propeller Key for Controller Settings

This record must follow Record (9) if controller settings are being given as input.

"keyAziPropeller" keyAziPropeller (1 character string, 1 integer)

"keyAziPropeller"	Record tag.
keyAziPropeller	Key of azimuthing propeller for which controller settings are being specified. If this key to set to "All", then the input controller settings are applied to all azimuthing propellers.

Record (9b), Azimuthing Propeller Deflection Controller Parameters

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a).

"deflectControlParam", deflectMaxDeg, deflectVelMaxDeg, deflectAccMaxDeg, deflectFreqResponse, deflectDampResponse, dtMax (1 character string, 6 floats)

"deflectControlParam"	Record tag.
deflectMaxDeg	Maximum deflection angle (deg). This value is typically set to 35°.
deflectVelMaxDeg	Maximum deflection velocity (deg/s). If this value is set to 0.0, then the maximum velocity is unlimited.
deflectAccMaxDeg	Maximum deflection acceleration (deg/s^2). If this value is set to 0.0, then the maximum acceleration is unlimited.
deflectFreqResponse	Undamped response frequency of deflection controller.
deflectDampResponse	Damping of deflection controller as a fraction of critical damping. This value is typically between 0.5 and 1.0.
deflectDtMax	Maximum time increment for time stepping of azimuthing propeller deflections. This parameter doesn't affect frequency domain computations with SM3DSeakeepSeaway.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9c), Azimuthing Propeller Deflection Controller Displacement Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a)

"deflectDispGains", surgeGain, swayGain, heaveGain, rollGain, pitchGain, yawGain (1 character string, 6 floats)

"deflectDispGains"	Record tag.
surgeGain	Surge gain (deg/m). This value should be 0.0.
swayGain	Sway gain (deg/m). This value should be 0.0.
heaveGain	Heave gain (deg/m). This value is typically 0.0.
rollGain	Roll gain (deg/deg). This value is typically 0.0 unless roll stabilization is desired.
pitchGain	Pitch gain (deg/deg). This value is typically 0.0.
yawGain	Yaw gain (deg/deg). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a ship using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9d), Azimuthing Propeller Deflection Controller Velocity Gains

This record can optionally be entered if an azimuthing propeller controller key has been specified using Record (9a).

"deflectVelGains", surgeVelGain, swayVelGain, heaveVelGain, rollVelGain, pitchVelGain, yawVelGain (1 character string, 6 floats)

"deflectVelGains"	Record tag.
surgeVelGain	Surge velocity gain (deg/(m/s)). This value should be 0.0.
swayVelGain	Sway velocity gain (deg/(m/s)). This value should be 0.0.
heaveVelGain	Heave velocity gain (deg/(m/s)). This value is typically 0.0.
rollVelGain	Roll velocity gain (deg/(deg/s)). This value is typically 0.0 unless stabilization is desired.
pitchVelGain	Pitch velocity gain (deg/(deg/s)). This value is typically 0.0.
yawVelGain	Yaw velocity gain (deg/(deg/s)). Note that the input yaw gain is defined according to ship motions in earth-fixed axes, for which positive yaw motion is clockwise. For a ship using a downward oriented azimuthing propeller for course keeping, this value is typically ≤ 0.0.
Note:	If this record is not included after Record (9a), then the original values for the given azimuthing propeller controller are used.

Record (9e), End of Azimuthing Propeller Controller Settings

"end aziPropellerDeflectControllerSettings" (2 character strings)

Record (10), Minimum Wave Encounter Frequency

"enFreqMinMotion", enFreqMinMotion (1 character string, 1 float)

"enFreqMinMotion"	Record tag.
enFreqMinMotion	Minimum wave encounter frequency for ship motion predictions. If the combination of ship speed, heading, and wave frequency gives an encounter frequency less than this value, then the wave frequency is shifted. This variable is used to avoid large amplitude motions at very low encounter frequencies. A value of approximately $0.3\sqrt{g/L}$ is recommended.

Record (11a), Ship Speed Range in m/s

One of Records (11a) to (11f) must be given.

"speedRange", speedMin, speedMax, speedInc (1 character string, 3 floats)

"speedRange"	Record tag.
speedMin	Minimum ship speed (m/s).
speedMax	Maximum ship speed (m/s).
speedInc	Increment for ship speed (m/s).

Record (11b), Ship Speeds in m/s

One of Records (11a) to (11f) must be given.

"speeds", speeds (1 character string, array of floats)

"speeds"	Record tag.
speeds	Array of ship speeds (m/s).

Record (11c), Ship Speed Range in Knots

One of Records (11a) to (11f) must be given.

"speedKnotsRange", speedKnotsMin, speedKnotsMax, speedKnotsInc (1 character string, 3 floats)

"speedKnotsRange"	Record tag.
speedKnotsMin	Minimum ship speed (knots).
speedKnotsMax	Maximum ship speed (knots).
speedKnotsInc	Increment for ship speed (knots).

Record (11d), Ship Speeds in Knots

One of Records (11a) to (11f) must be given.

"speedsKnots", speedsKnots (1 character string, array of floats)

"speedsKnots"	Record tag.
speedsKnots	Array of ship speeds (knots).

Record (11e), Froude Number Range

One of Records (11a) to (11f) must be given.

"FroudeRange", froudeMin, froudeMax, froudeInc (1 character string, 3 floats)

"FroudeRange"	Record tag.
froudeMin	Minimum Froude number.
froudeMax	Maximum Froude number.
froudeInc	Froude number increment.

Record (11f), Ship Froude Numbers

One of Records (11a) to (11f) must be given.

"Froudes", froudes (1 character string, array of floats)

"Froudes"	Record tag.
froudes	Array of ship Froude numbers.

Record (12a), Range of Ship Headings

One of Records (12a) or (12b) must be given.

"shipHeadingRange", shipHeadingDegMin, shipHeadingDegMax, shipHeadingDegInc (1 character string, 3 floats)

"shipHeadingRange"	Record tag.
shipHeadingDegMin	Minimum ship heading (to, deg).
shipHeadingDegMax	Maximum ship heading (to, deg).
shipHeadingDegInc	Increment for ship heading (to, deg).
Note:	The ship heading convention is 0° for the ship heading north, 90° for the ship heading east.

Record (12b), Ship Headings

One of Records (12a) or (12b) must be given.

“shipHeadingsDeg”, shipHeadingsDeg (1 character string, array of floats)

“shipHeadingsDeg”	Record tag.
shipHeadingsDeg	Array of ship headings (deg). The ship heading convention is 0° for the ship heading north, 90° for the ship heading east.

Record (13), Seaway Option

“spectrumOption”, spectrumOption (2 character strings)

“spectrumOption”	Record tag.
spectrumOption	Type of seaway. UniSpectrum - Unidirectional seaway based on input spectrum. CosSpectrum - Directional spectrum describe by a point wave spectrum and cosine-squared spreading function. DirSpectrum - Directional seaway with specified directional properties.

Record (14), Beginning of Unidirectional Wave Spectrum

Records (14) to (14d) are required if spectrumOption is set to UniSpectrum in Record (13).

“begin uniSpectrum” (1 character string with 2 words)

Record (14a), Wave Heading

This record is required if seawayOption in Record (13) is set to UniSpectrum.

“waveHeading”, waveHeadingFromDeg (1 character string, 1 float)

“waveHeading”	Record tag.
waveHeadingFromDeg	Wave direction ν (from, degrees). 0° for waves from north, and 90° for waves from east.

Record (14b), Unidirectional Wave Spectrum Option

This record is required if spectrumOption in Record (13) is set to UniSpectrum.

"uniSpectrumOption", uniSpectrumOption (2 character strings)

"uniSpectrumOption"	Record tag.
uniSpectrumOption	Type of unidirectional wave spectrum.
	Bretschneider - Unidirectional Bretschneider wave spectrum.
	JONSWAP - Unidirectional JONSWAP wave spectrum.
	OchiHubble - Unidirectional Ochi and Hubble six parameter wave spectrum.
	Input - Unidirectional user-input wave spectrum.

Record (14c1), Unidirectional Bretschneider Spectrum Seaway Parameters

This record is required if uniSpectrumOption in Record (14b) is set to Bretschneider.

"BretParam", hs, tp (1 character string, 2 floats)

"BretParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).

Record (14c2), Unidirectional JONSWAP Spectrum Seaway Parameters

This record is required if uniSpectrumOption in Record (14b) is set to JONSWAP.

"JONSWAPParam", hs, tp, peakEnhance (1 character string, 3 floats)

"JONSWAPParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).
peakEnhance	Peak enhancement factor γ. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (14c3), Unidirectional Ochi Hubble Spectrum Parameters

This record is required if uniSpectrumOption in Record (14b) is set to OchiHubble.

"OchiHubbleParam", hs1, freqPeak1, spectralShape1, hs2, freqPeak2, spectralShape2 (1 character string, 6 floats)

"OchiHubbleParam"	Record tag.
hs1	Significant wave height h_{s-1} of wave system 1 (m).
freqPeak1	Peak wave frequency ω_{p-1} of wave system 1 (rad/s).
spectralShape1	Spectral shape factor λ_1 of wave system 1.
hs2	Significant wave height h_{s-2} of wave system 2 (m).
freqPeak2	Peak wave frequency ω_{p-2} of wave system 2 (rad/s).
spectralShape2	Spectral shape factor λ_2 of wave system 2.

Record (14c4), Unidirectional Input Spectrum Wave Frequencies

This record is required if uniSpectrumOption in Record (14b) is set to Input.

"inputWaveFreqs", inputWaveFreqs (1 character string, array of floats)

"inputWaveFreqs"	Record tag.
inputWaveFreqs	Wave frequencies ω_I for input energy densities (rad/s).

Record (14c5), Unidirectional Input Spectrum Energy Densities

This record is required if uniSpectrumOption in Record (14b) is set to Input

"inputEnergyDensities", inputEnergyDensities (1 character string, array of floats)

"inputEnergyDensities"	Record tag.
inputEnergyDensities	Wave spectrum energy densities $S_{\omega_I}(\omega_I)$ corresponding to wave frequencies of Record (14c4).

Record (14d), End of Unidirectional Wave Spectrum

This record is required if spectrumOption is set to UniSpectrum in Record (13).

"end uniSpectrum" (1 character string with 2 words)

Record (15), Beginning of Cosine-squared Spreading Wave Spectrum

Records (15) to (15d) are required if spectrumOption is set to CosSpectrum in Record (13).

"begin cosSpectrum" (1 character string with 2 words)

Record (15a), Mean Wave Heading

This record is required if seawayOption in Record (13) is set to CosSpectrum.

"waveHeadingMean", waveHeadingMeanDeg (1 character string, 1 float)

"waveHeadingMean"	Record tag.
waveHeadingMeanDeg	Mean wave direction ν (from, degrees). $0°$ for waves from north, and $90°$ for waves from east.

Record (15b), Wave Spreading Angle

This record is required if spectrumOption in Record (13) is set to CosSpectrum.

"spreadAngle", spreadAngleDeg (1 character string, 1 float)

"spreadAngle"	Record tag.
spreadAngleDeg	Directional spreading angle (deg).

Record (15c), Cosine-Squared Wave Spectrum Option

This record is required if spectrumOption in Record (13) is set to CosSpectrum.

"cosSpectrumOption", cosSpectrumOption (2 character strings)

"cosSpectrumOption"	Record tag.
cosSpectrumOption	Type of wave spectrum with cosine-squared directional spreading: CosBretschneider - Bretschneider wave spectrum with cosine-squared directional spreading. CosJONSWAP - JONSWAP wave spectrum with cosine-squared directional spreading.

Record (15c1), Cosine-squared Bretschneider Spectrum Parameters

This record is required if cosSpectrumOption in Record (15c) is set to CosBretschneider.

"BretParam", hs, tp (1 character string, 2 floats)

"BretParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).

Record (15c2), Cosine-squared JONSWAP Spectrum Seaway Parameters

This record is required if cosSpectrumOption in Record (15c) is set to CosJONSWAP.

"JONSWAPParam", hs, tp, peakEnhance (1 character string, 3 floats)

"JONSWAPParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).
peakEnhance	Peak enhancement parameter γ. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (15d), End of Cosine-squared Spreading Wave Spectrum

This record is required if spectrumOption is set to CosSpectrum in Record (13).

"end cosSpectrum" (1 character string with 2 words)

Record (16), Beginning of Directional Wave Spectrum

Records (16) to (16d) are required if spectrumOption is set to DirSpectrum in Record (13).

"begin dirSpectrum" (1 character string with 2 words)

Record (16a), Directional Wave Spectrum Option

This record is required if spectrumOption in Record (13) is set to DirSpectrum.

"dirSpectrumOption", dirSpectrumOption (2 character strings)

"dirSpectrumOption"	Record tag.
dirSpectrumOption	Type of unidirectional wave spectrum: TenParameter - Ten parameter spectrum from Hogben and Cobb [23]. EndecoWaveBuoy - Directional spectrum from Endeco wave buoy. InputDir - Input directional spectrum.

Record (16a1), Ten Parameter Spectrum Parameters

This record is required if dirSpectrumOption in Record (16a) is set to TenParameter.

"tenParamParam", hs1, freqPeak1, spectralShape1, waveHeadingMeanDeg1, dirSpreadExp1, hs2, freqPeak2, spectralShape2, waveHeadingMeanDeg2, dirSpreadExp2 (1 character string, 10 floats)

"tenParamParam"	Record tag.
hs1	Significant wave height h_{s-1} of wave system 1 (m).
freqPeak1	Peak wave frequency ω_{p-1} of wave system 1 (rad/s).
spectralShape1	Spectral shape factor λ_1 of wave system 1.
waveHeadingMeanDeg1	Principle wave direction $\overline{\nu_1}$ (from, degrees) of wave system 1. 0° for waves from north, and 90° for waves from east.
dirSpreadExp1	Directional spreading exponent P_1 of wave system 1.
hs2	Significant wave height h_{s-2} of wave system 2 (m).
freqPeak2	Peak wave frequency ω_{p-2} of wave system 2 (rad/s).
spectralShape2	Spectral shape factor λ_2 of wave system 2.
waveHeadingMeanDeg2	Principle wave direction $\overline{\nu_2}$ (from, degrees) of wave system 2. 0° for waves from north, and 90° for waves from east.
dirSpreadExp2	Directional spreading exponent P_2 of wave system 2.

Record (16b), Endeco Wave Buoy Spectrum File Name

This record is required if spectrumOption in Record (13) is set to EndecoWaveBuoy.

"EndecoSpectrumFileName", EndecoSpectrumFileName (2 character strings)

"EndecoSpectrumFileName"	Record tag.
EndecoSpectrumFileName	File name of directional wave spectrum file produced by Endeco 956 or 1156 wave buoy. The file name will typically have the extension ".std".

Record (16c), Input Directional Wave Spectrum File Name

This record is required if spectrumOption in Record (13) is set to inputDir.

"inputDirSpectrumFileName", inputDirSpectrumFileName (2 character strings)

"inputDirSpectrumFileName"	Record tag.
inputDirSpectrumFileName	Input directional wave spectrum file name. The format of the directional wave spectrum file is given in Annex A.2.

Record (16d), End of Directional Wave Spectrum

This record is required if spectrumOption is set to DirSpectrum in Record (13).

"end dirSpectrum" (1 character string with 2 words)

Record (17a), Range of Incident Wave Frequencies for Integration of Ship Motion Spectrum

One of Records (17a) or (17b) must be given.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc (1 character string, 3 floats)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum incident wave frequency (rad/s).
waveFreqMax	Maximum incident wave frequency (rad/s).
waveFreqInc	Increment for incident wave frequency (rad/s).

Record (17b), Incident Wave Frequencies for Integration of Ship Motion Spectrum

One of Records (17a) or (17b) must be given.

"waveFreqs", waveFreqs (1 character string, array of floats)

"waveFreqs"	Record tag.
waveFreqs	Array of increasing incident wave frequencies (rad/s).

Record (18a), Wave Direction Range for Integration of Ship Motion Spectrum

If spectrumOption in Record (13) is set to CosSpectrum or DirSpectrum, then one of Records (18a) or (18b) must be given.

"waveDirFromRange", waveDirFromDegMin, waveDirFromDegMax, waveDirFromDegInc (1 character string, 3 floats)

"waveDirFromRange"	Record tag.
waveDirFromDegMin	Minimum wave direction (deg).
waveDirFromDegMax	Maximum wave direction (deg).
waveDirFromDegInc	Wave direction increment (deg).
Note:	Wave directions are given using a convention of 0° for waves from north, 90° for waves from east.

Record (18b), Wave Directions Integration of Ship Motion Spectrum

If spectrumOption in Record (13) is set to CosSpectrum or DirSpectrum, then one of Records (18a) or (18b) must be given.

"waveDirsFrom", waveDirsFromDeg (1 character string, array of floats)

"waveDirsFrom"	Record tag.
waveDirsFromDeg	Wave directions for integration of ship motion spectrum. Wave directions are given using a convention of 0° for waves from north, 90° for waves from east.

Record (19), Beginning of Steady Forward Speed Sinkage and Trim Data

Records (19) to (19b) can optionally be used to give ship sinkage and trim data.

"begin steadySinkageTrim" (1 character string with 2 words)

Record (19a), Sinkage and Trim for Ship Speed

This record is repeated once for every ship speed with sinkage and trim data, with increasing ship speeds.

"speedSinkageTrim", speedSinkageTrim, heaveSteady, pitchSteadyDeg (1 character string, 3 floats)

"speedSinkageTrim"	Record tag.
speedSinkageTrim	Speed for which sinkage and trim values are given (m/s)
heaveSteady	Heave at steady speed (m, + up).
pitchSteadyDeg	Pitch at steady speed (deg, + bow down).

Record (19b), End of Steady Sinkage and Trim Data

This record is required if Records (19) and (19a) are included.

"end steadySinkageTrim" (1 character string with 2 words)

Record (20), Beginning of Steady Forward Speed Wave Elevation Data

Records (20) to (20d) can optionally be used to give ship steady wave profile data data.

"begin steadyWaveProfile" (1 character string with 2 words)

Record (20a), Stations for Steady Wave Elevation Data

This record is required if steady wave elevation data are being given.

"stationsSteadyWaveProfile", stationsSteadyWaveProfile (1 character string, nStationSteadyWaveProfile floats)

"stationsSteadyWaveProfile"	Record tag.
stationsSteadyWaveProfile	Ship stations for steady wave elevation data.

Record (20b), Speeds in m/s for Steady Wave Elevation Data

This record is required if steady wave elevation data are being given.

"speedsSteadyWaveProfile", speedsSteadyWaveProfile (1 character string, nSpeedSteadyWaveProfile floats)

"speedsSteadyWaveProfile"	Record tag.
speedsSteadyWaveProfile	Ship speeds for steady wave elevation data (m/s).

Record (20c), Steady Wave Elevation Profile Data

This record must be given for each station with steady wave elevation data.

"stationSteadyWaveElevs", stationSteadyWave, waveElevsSteady (1 character string, 1 + nSpeedSteadyWaveProfile floats)

"stationSteadyWaveElevs"	Record tag.
stationSteadyWave	Station number for input wave elevations. This value must be consistent with values given in Record (20a).
waveElevsSteady	Wave elevations (m) at stationSteadyWave for ship speeds specified in Record (20b).

Record (20d), End of Steady Wave Profile Data

This record is required if Record (20) and subsequent records have been entered.

"end steadyWaveProfile" (1 character string with 2 words)

Record (21), Beginning of Seakeeping Position Data

This record is optional.

"begin seakeepPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (21a) to (21f6) giving seakeeping position parameters. Record (21g) must follow at the end of all seakeeping position data.

Record (21a), Seakeeping Position Label

This record is required if a seakeeping position is being specified.

"labelPos", labelPos (2 character strings)

"labelPos"	Record tag.
labelPos	Label for seakeeping position. This can include spaces.

Record (21b), Seakeeping Position Location

This record is required if a seakeeping position is being specified.

"locationPos", stationPos, yPos, zBlPos (1 character string, 3 floats)

"locationPos"	Record tag.
stationPos	Station for seakeeping position. Station 0 is at the fore perpendicular.
yPos	Lateral coordinate (+ port) relative to ship centreline (m).
zBlPos	Vertical coordinate (+ up) relative to ship baseline (m).

Record (21c), Option for Radiation and Diffraction when Evaluating Relative Vertical Motion

This record is optional if a seakeeping position is being specified.

"relMoRadDifOption" relMoRadDifOption (2 character strings)

"relMoRadDifOption"	Record tag.
relMoRadDifOption	Option for including radiation and diffraction in relative vertical motion: NoRadDif - Wave radiation and diffraction are not considered when evaluating relative wave motion (default).

Record (21d), Option for Including the Steady Wave Due to Ship Forward Speed when Evaluating Wetness or Emergence Events

This record is optional if a seakeeping position is being specified.

"relWaveElevSteadyOption", relWaveElevSteadyOption (2 character strings)

"relWaveElevSteadyOption"	Record tag.
relWaveElevSteadyOption	Option for including the influence of the steady wave field due to ship forward speed when evaluating distance from the waterline in calm water:
	NoSteadyWave - The steady wave due to ship forward speed is not included (default). This option must be used if no steady wave data are provided in Records (19) to (20d).
	SinkageTrimOnly - The ship sinkage and trim due to ship forward speed are included when evaluated vertical position relative to the calm waterline. Sinkage and trim values specified in input Records (19) to (19b).
	SteadyWaveElev - The steady wave elevation is evaluated based on steady wave profile specified in Records (20) to (20d). Sinkage and trim from Records (19) to (19b) are included.

Record (21e), Option for Motion-Induced Interruptions

This record is required if a seakeeping position is being specified.

"miiOption", miiOption (2 character strings)

"miiOption"	Record tag.
miiOption	Option for motion-induced interruption computations:
	Mii - Motion-induced interruption computations are performed.
	NoMii - No motion-induced interruption computations are performed.

Record (21e1), Parameters for Motion-Induced Interruptions

This record is required if miiOption is set to mii in Record (21e).

"miiParam", tipCoLat, tipCoLong, durationMii (1 character strings, 3 floats)

"miiParam"	Record tag.
tipCoLat	Lateral tipping coefficient. A value of 0.25 is typically used for humans facing forward.
tipCoLong	Longitudinal tipping coefficient. A value of 0.17 is typically used for humans facing forward.
durationMii	Duration for computing incidence of motion-induced interruptions (s). A value of 60 s is typically used.
Note:	For sliding calculations, the user should set tipCoLat and tipCoLong equal to the static coefficient of friction.

Record (21f), Option for Slamming, Deck Wetness, or Emergence Computations

This record is required if a seakeeping position is being specified.

"slamWetEmergeOption", slamWetEmergeOption (2 character strings)

"slamWetEmergeOption"	Record tag.
slamWetEmergeOption	Option for slamming, deck wetness, or emergence computations: NoSlamWetEmerge - No slamming, deck wetness, or emergence computations are performed. SlamPressureCoWidth - Slamming calculations are performed using an input slamming form factor and effective pressure width specified in Record (21f2). SlamWedge - Slamming calculations are performed using wedge dimensions given in Record (21f3). SlamOffsets - Slamming calculations are performed using offsets given in Records (21f4), (21f5), and (21f6). WetnessEmerge - Incidence of wetness or emergence calculations are performed, depending on whether the position is above or below the waterline.

Record (21f1), Duration and Exceedence Probability for Slamming, Wetness, or Emergence Statistics

This record is required if slamWetEmergeOption in Record (21f) is set to SlamPressureCoWidth, SlamWedge, SlamOffsets, or WetnessEmerge.

“durationPExceed”, durationHours, pExceed (1 character string, 2 floats)

“durationPExceed”	Record tag.
durationHours	Duration for slamming, wetness, or emergence statistics (hours).
pExceed	Exceedence probability for slamming, wetness, or emergence statistics.

Record (21f2), Slamming Pressure Coefficient and Effective Pressure Width

This record is required if slamWetEmergeOption in Record (21f) is set to SlamPressureCoWidth.

“slamPressureCoWidth”, slamPressureCo, slamForceWidth (1 character string, 2 floats)

“slamPressureCoWidth”	Record tag.
slamPressureCo	Slamming pressure coefficient.
slamForceWidth	Effective slamming force width (m).

Record (21f3), Wedge Geometry for Slamming Calculations

This record is required if slamWetEmergeOption in Record (21f) is set to SlamWedge.

“slamWedge”, deadRiseDeg, slamForceHeight (1 character string, 2 floats)

“slamWedge”	Record tag.
deadRiseDeg	Hull deadrise angle at keel (degrees). This value must be greater than 0 degrees. For deadrise angles less than 5 degrees, this approach can be inaccurate, and is recommended that either the slamForm or slamOffsets option be used instead for slamWetEmergeOption in Record (21f).
slamForceHeight	Height above the keel at which slamming pressure goes to zero (typically taken as $0.1T_x$, where T_x is the sectional draft).

Record (21f4), Elevation Above Baseline for Zero Slamming Pressure

This record is required if slamWetEmergeOption in Record (21f) is set to SlamOffsets.

"zBlZeroSlamPres", zBlZeroSlamPres (1 character string, 1 float)

"zBlZeroSlamPres"	Record tag.
zBlZeroSlamPres	Elevation above baseline at which slamming pressure goes to zero (m). This value is typically assumed to be at a height of $0.1T_x$ above the baseline, where T_x is sectional draft.

Record (21f5), Y Offsets for Performing Slamming Calculations

This record is required if slamWetEmergeOption in Record (21f) is set to SlamOffsets.

"yOffsetsSlam", yOffsetsSlam (1 character string, array of floats)

"yOffsetsSlam"	Record tag.
yOffsetsSlam	Horizontal offsets for points going from keel to at least zBlZeroSlamPres (Record (21f4)) above the baseline (m).

Record (21f6), Z Offsets for Performing Slamming Calculations

This record is required if slamWetEmergeOption in Record (21f) is set to SlamOffsets.

"zBlOffsetsSlam", zBlOffsetsSlam (1 character string, array of floats)

"zBlOffsetsSlam"	Record tag.
zBlOffsetsSlam	Vertical offsets for points going from keel to at least zBlZeroSlamPres (Record (21f4)) above the baseline (m).

Record (21g), End of Seakeeping Position Data

This record is required if Record (21) is present.

"end seakeepPositions" (1 character string with 2 words)

Record (22), End Record

"end SM3DSeakeepSeaway3"(1 character string with 2 words)

E.2 Sample Input File for SM3DSeakeepSeaway3

```
begin SM3DSeakeepSeaway3
label Generic frigate
shipDBFileName genFrigShipForMotionDB.bin
lengthData 120.000 20.000
loadCondition 1025.000 4.200 0.000 6.000  0.0000
enFreqMinMotion 0.1
speedKnotsRange 10 30 10
shipHeadingRange 0 345 15
spectrumOption DirSpectrum
begin dirSpectrum
    dirSpectrumOption TenParameter
    tenParamParam 3 0.6 1 110 1 4 0.4 1 160 1
end dirSpectrum
waveFreqRange 0.2 2 0.05
waveDirFromRange 0 360 10
begin seakeepPositions
labelPos Seakeeping position
    locationPos 3 2 12
    relMoRadDifOption NoRadDif
    relWaveElevSteadyOption NoSteadyWave
    miiOption Mii
    miiParam 0.25 0.17 60
    motionSicknessOption MotionSickness
    tDayMotionSickness 0.25
    slamWetEmergeOption WetnessEmerge
    durationPExceed 1 0.01
end seakeepPositions
end SM3DSeakeepSeaway3
```

E.3 Sample Output File for SM3DSeakeepSeaway3 (Motions Only Given for One Ship Speed, Directional Seaway Spectral Densities Removed)

```
Program SM3DSeakeepSeaway3
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-10-11 9:08:02 AM
Run label:
Generic frigate

**** ECHO OF USER INPUT ****

Input ship for motion database file name:
genFrigShipForMotionDB.bin
Label   : Generic frigate
Created : November-09-11 8:19:55 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.ShipForMotionDB

Ship Length Data
Length between perpendiculars :   120.000 m
Station of aft perpendicular  :    20.000

Ship Loading Condition
Water density : 1025.000 kg/m3
Draft of baseline at midships       :     4.200 m
Trim of baseline by stern           :     0.000 m
Height of CG above baseline, KG     :     6.000 m
Correction to metacentric height GM :     0.000 m

Minimum wave encounter frequency for predicting ship motions : 0.100 rad/s

Speed range
Minimum   :   10.000 knots
Maximum   :   30.000 knots
Increment :   10.000 knots

Sea direction range
Minimum   :    0.000 deg
Maximum   :  345.000 deg
Increment :   15.000 deg

Seaway
Spectrum type :
Directional spectrum type :
Ten parameter spectrum parameters
Wave system                          1              2
Significant wave height     :     3.000 m         4.000 m
Peak wave frequency         :     0.600 rad/s     0.400 rad/s
```

```
Spectral shape factor       :     1.000           1.000
Mean wave direction (from)  :   110.000 deg     160.000 deg
Directional spread exponent :     1.000           1.000

Incident wave frequency range for integration of ship motion spectra
Minimum   :    0.200 rad/s
Maximum   :    2.000 rad/s
Increment :    0.050 rad/s

Incident wave direction range (from) for integration of ship motion spectra
Minimum   :    0.000 deg
Maximum   :  360.000 deg
Increment :   10.000 deg

Seakeeping Positions

Label               : Seakeeping position
Station             :     3.000
Lateral offset y    :     2.000 m (+ port)
Vertical offset zBl :    12.000 m (+ up, relative to baseline)
Option for including radiation and diffraction for relative motion : NoRadDif
                                                                     (input)
Option for including steady wave due to ship forward speed : NoSteadyWave (input)
Option for motion-induced interruption computations : Mii
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Duration for MII incidence       :      60.0 s
Option for motion sickness computations : MotionSickness
Parameters for motion sickness
Exposure time :     0.250 days
Option for slamming, wetness, or emergence computations : WetnessEmerge
Parameters for slamming, wetness or emergence statistics
Duration               :     1.000 hours
Exceedence probability :  0.010000

**** SHIP LOADING CONDITION ****

Load Condition Properties for Trimmed Ship

Summary of hydrostatic properties
Number of panels on port side        :          613
Total number of panels               :         1226
Length between perpendiculars        :      120.000 m
Draft of baseline at midships        :        4.200 m
Trim of baseline by stern            :        0.000 m
Beam based on maximum y value        :       14.111 m
Volume                               :     3622.358 m3
Water density                        :     1025.000 kg/m3
Mass                                 : 3712916.723463 kg
Distance from FP to X origin (m)     :       61.750 m
```

```
(Origin located at LCG)
Station of X origin                 :       10.292
Center of buoyancy wrt waterline    :       -1.614 m
Wetted surface area                 :     1753.438 m2
Waterplane area                     :     1344.310 m2
X value of center of floatation     :       -5.022 m
Integral of waterplane area*X**2    :  1234204.219 m4
Integral of waterplane area*Y**2    :    17543.814 m4
KG, height of CG above baseline     :        6.000 m
Height of CG above waterline        :        1.800 m
Metacentric height from hydrostatics :       1.430 m

Inertial Properties

Inertia matrix, units of kg, kg*m, and kg*m2
   3712916.7          0.0          0.0          0.0          0.0          0.0
         0.0    3712916.7          0.0          0.0          0.0          0.0
         0.0          0.0    3712916.7          0.0          0.0          0.0
         0.0          0.0          0.0   85545601.3          0.0          0.0
         0.0          0.0          0.0          0.0 3341625051.1          0.0
         0.0          0.0          0.0          0.0          0.0 3341625051.1

Roll radius of gyration  :     4.800 m
Pitch radius of gyration :    30.000 m
Yaw radius of gyration   :    30.000 m

Roll Metacentric Height Properities

)Roll metacentric height from hull hydrostatics :     1.430 m
Correction due to sloshing tanks               :     0.000 m
Input correction to roll metacentric height    :     0.000 m
Corrected metacentric height                   :     1.430 m


Roll Properties at Zero Forward Speed

Roll added mass                       : 19548240.530169 kg*m**2
Nondimensional roll added mass A44/I44 :     0.229
Natural roll frequency                :     0.704 rad/s
Natural roll period                   :     8.928 s


**** SHIP AUTOPILOT SETTINGS ****

Rudder Autopilots for Ship

Autopilot for ship with nominally steady speed and heading
Key   : Rudder
Label : Rudder
Maximum deflection   :    35.000 deg
Maximum velocity     :     3.000 deg/s
```

```
Maximum acceleration :   Not set deg/s2
Response frequency   :     3.000 rad/s
Response damping     :     0.850 rad/s (fraction of critical)
Maximum time step    :     0.100 s
Autopilot gains
Displacement gains have units of deg/m and deg/deg
Velocity gains have units of deg/(m/s) and deg/(deg/s)
Yaw gains given relative to earth-fixed axes (+yaw is clockwise)
                        Surge     Sway    Heave     Roll    Pitch      Yaw
Displacement gains :    0.000    0.000    0.000    0.000    0.000   -4.000
Velocity gains     :    0.000    0.000    0.000    0.000    0.000   -8.000


**** SEAKEEPING POSITION TRIM CONDITIONS ****

Label           : Seakeeping position
Station         :     3.000
x wrt ship CG   :    43.750 m
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Time of operation                :    60.000 s
Parameters motion sickness
Time for motion sickness               :     0.250 days


**** DIRECTIONAL WAVE SPECTRUM ****

Ten parameter directional wave spectrum
Significant wave height  :     5.000 m
Wave system                         1               2
Significant wave height        :     3.000 m         4.000 m
Peak wave frequency            :     0.600 rad/s     0.400 rad/s
Spectral shape parameter       :     1.000 deg       1.000 deg
Mean wave direction (from)     :   110.000         160.000
Directional spreading exponent :     1.000           1.000
Significant wave height based on directional wave spectrum area :     4.984 m

Wave frequency       Spectral density
 (rad/s)                m2/(rad/s)
       0.200            0.000
       0.250            0.036
       0.300            1.013
       0.350            2.888
       0.400            3.641
       0.450            3.553
       0.500            3.318
```

0.550	3.013
0.600	2.616
0.650	2.177
0.700	1.760
0.750	1.399
0.800	1.103
0.850	0.868
0.900	0.684
0.950	0.541
1.000	0.431
1.050	0.345
1.100	0.278
1.150	0.226
1.200	0.185
1.250	0.152
1.300	0.126
1.350	0.105
1.400	0.088
1.450	0.074
1.500	0.063
1.550	0.053
1.600	0.046
1.650	0.039
1.700	0.034
1.750	0.029
1.800	0.026
1.850	0.022
1.900	0.020
1.950	0.017
2.000	0.015

**** Motions at Ship CG in a Seaway ****

Ship speed :   10.300 m/s (20.000 knots, Froude number 0.300)
Ship heading (to) is in earth-fixed axes.
0 degrees for ship heading north, 90 degrees for ship heading east
RMS Displacements and Zero-crossing Periods

Ship heading	Surge		Sway		Heave		Roll		Pitch		Yaw	
(deg)	(m)	(s)	(m)	(s)	(m)	(s)	(deg)	(s)	(deg)	(s)	(deg)	(s)
0.0	1.97	26.3	0.90	16.8	1.01	11.0	5.34	11.8	1.01	8.8	1.20	16.5
15.0	1.89	26.1	0.87	16.1	1.03	10.5	5.16	11.7	1.06	8.2	1.15	16.2
30.0	1.75	25.5	0.84	15.5	1.04	10.1	5.03	11.5	1.10	7.7	1.09	15.8
45.0	1.62	25.1	0.80	14.7	1.06	9.7	4.81	11.4	1.15	7.4	1.02	15.3
60.0	1.44	24.1	0.76	13.9	1.08	9.3	4.65	11.2	1.20	7.1	0.94	14.7
75.0	1.27	23.1	0.72	13.2	1.10	9.0	4.44	11.0	1.24	6.9	0.86	14.0
90.0	1.09	21.6	0.69	12.6	1.12	8.8	4.31	10.9	1.28	6.8	0.79	13.3
105.0	0.92	20.0	0.67	12.0	1.13	8.7	4.10	10.8	1.30	6.7	0.74	12.7
120.0	0.78	18.2	0.65	11.7	1.14	8.6	4.09	10.5	1.32	6.7	0.69	12.3
135.0	0.71	17.2	0.65	11.6	1.15	8.6	4.09	10.6	1.32	6.7	0.68	12.0
150.0	0.72	17.3	0.66	11.7	1.14	8.6	4.18	10.6	1.32	6.7	0.71	12.3
165.0	0.81	18.8	0.68	12.2	1.14	8.7	4.26	10.7	1.30	6.8	0.76	12.8
180.0	0.95	20.4	0.72	12.8	1.13	8.8	4.43	10.8	1.28	6.9	0.82	13.5
195.0	1.15	22.6	0.75	13.4	1.11	9.0	4.57	11.0	1.25	7.1	0.89	14.2
210.0	1.33	23.9	0.79	14.1	1.09	9.2	4.78	11.2	1.20	7.3	0.96	14.8
225.0	1.52	25.1	0.83	14.9	1.07	9.6	4.92	11.4	1.16	7.6	1.03	15.3
240.0	1.66	25.5	0.87	15.7	1.05	9.9	5.11	11.5	1.11	8.0	1.10	15.9
255.0	1.82	26.2	0.89	16.3	1.03	10.4	5.20	11.7	1.07	8.5	1.17	16.3
270.0	1.92	26.3	0.92	17.0	1.01	10.9	5.41	11.8	1.02	9.1	1.22	16.6
285.0	2.02	26.7	0.94	17.3	1.00	11.4	5.47	11.9	0.99	9.7	1.25	16.7
300.0	2.06	26.6	0.95	17.6	0.99	11.8	5.56	11.9	0.96	10.3	1.27	16.9
315.0	2.10	26.9	0.95	17.6	0.99	11.9	5.53	11.9	0.96	10.4	1.28	16.9
330.0	2.08	26.6	0.94	17.5	0.99	11.8	5.53	11.9	0.96	10.1	1.27	16.9
345.0	2.06	26.7	0.92	17.2	1.00	11.5	5.42	11.9	0.98	9.5	1.24	16.7

Rudder RMS Deflections and Zero-crossing Periods
Rudder keys and labels
Key   Label

Rudder Rudder

Ship heading	Rudder Deflection (deg)	Tz (s)
0.0	5.97	14.0
15.0	5.76	13.5
30.0	5.47	13.0
45.0	5.19	12.3
60.0	4.85	11.7
75.0	4.56	11.0
90.0	4.28	10.3
105.0	4.05	9.8
120.0	3.86	9.5
135.0	3.85	9.4
150.0	3.95	9.6
165.0	4.16	10.0
180.0	4.40	10.6
195.0	4.70	11.2
210.0	4.98	11.9
225.0	5.28	12.5
240.0	5.55	13.2
255.0	5.85	13.8
270.0	6.06	14.2
285.0	6.21	14.5
300.0	6.28	14.7
315.0	6.32	14.7
330.0	6.26	14.6
345.0	6.16	14.3

Seakeeping at Position on Ship

```
Label          : Seakeeping position
Station        :     3.000
x wrt ship CG  :    43.750 m
```

```
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Time of operation                :    60.000 s
Parameters motion sickness
Time for motion sickness               :     0.250 days
RMS Motions at Seakeeping Position

Position label : Seakeeping position
```

Ship	*** Longitudinal ***			*** Lateral ***			*** Vertical ***			** Relative Vertical **		
heading	Disp	Tz	Acc	Disp	Tz	Acc	Disp	Tz	Acc	Disp	Tz	Vel
(deg)	(m)	(s)	(g)	(m)	(s)	(g)	(m)	(s)	(g)	(m)	(s)	(m/s)
0.0	1.895	26.9	0.014	1.214	16.2	0.032	1.377	9.3	0.095	0.885	5.8	0.964
15.0	1.814	26.9	0.014	1.168	15.6	0.032	1.429	8.8	0.106	0.957	5.5	1.095
30.0	1.677	26.3	0.013	1.120	15.1	0.033	1.483	8.3	0.118	1.029	5.3	1.226
45.0	1.545	26.1	0.013	1.060	14.3	0.034	1.545	8.0	0.128	1.107	5.2	1.351
60.0	1.371	25.2	0.013	1.002	13.6	0.034	1.602	7.7	0.138	1.177	5.1	1.462
75.0	1.205	24.5	0.013	0.940	12.9	0.035	1.657	7.5	0.147	1.243	5.0	1.558
90.0	1.021	23.2	0.013	0.887	12.2	0.036	1.701	7.4	0.153	1.294	5.0	1.632
105.0	0.860	21.8	0.013	0.844	11.6	0.036	1.736	7.3	0.158	1.332	5.0	1.682
120.0	0.723	20.2	0.013	0.816	11.2	0.037	1.759	7.3	0.160	1.355	5.0	1.709
135.0	0.655	19.4	0.013	0.802	11.0	0.037	1.770	7.3	0.161	1.364	5.0	1.712
150.0	0.663	19.6	0.013	0.814	11.1	0.037	1.764	7.3	0.159	1.356	5.0	1.691
165.0	0.765	21.2	0.013	0.848	11.6	0.036	1.748	7.4	0.155	1.334	5.1	1.646
180.0	0.901	22.6	0.013	0.899	12.2	0.036	1.716	7.5	0.149	1.297	5.2	1.579
195.0	1.104	24.7	0.013	0.948	12.8	0.035	1.676	7.6	0.142	1.247	5.3	1.492
210.0	1.278	25.5	0.013	1.005	13.5	0.034	1.624	7.9	0.133	1.186	5.4	1.386
225.0	1.470	26.5	0.013	1.062	14.2	0.034	1.570	8.1	0.122	1.118	5.5	1.268
240.0	1.608	26.6	0.013	1.126	15.1	0.033	1.508	8.5	0.111	1.043	5.8	1.139
255.0	1.761	27.2	0.013	1.173	15.6	0.032	1.452	9.0	0.100	0.969	6.0	1.011
270.0	1.851	27.1	0.013	1.218	16.2	0.031	1.397	9.5	0.090	0.899	6.4	0.888

285.0	1.953	27.5	0.013	1.244	16.5	0.031	1.355	10.0	0.081	0.843	6.7	0.788
300.0	1.986	27.2	0.013	1.267	16.8	0.030	1.321	10.5	0.075	0.798	7.0	0.718
315.0	2.029	27.5	0.013	1.269	16.8	0.030	1.311	10.6	0.074	0.784	7.0	0.708
330.0	2.001	27.2	0.013	1.266	16.8	0.031	1.314	10.4	0.078	0.791	6.6	0.752
345.0	1.981	27.3	0.013	1.242	16.4	0.031	1.341	9.9	0.086	0.831	6.2	0.846

Forces Relative to Local Axes and Motion-Induced Interruptions

Position label : Seakeeping position

MIIs given as rate for following duration : 60.0 s
Lateral tipping coefficient : 0.250
Longitudinal tipping coefficient : 0.170

Ship heading	***** Lateral *****			***** Longitudinal *****			Total
	Force estimator		MIIs	Force estimator		MIIs	MIIs
	RMS (g)	Tz (s)		RMS (g)	Tz (s)		
0.0	0.103	10.0	0.8	0.015	5.1	0.0	0.8
15.0	0.100	9.9	0.7	0.016	5.1	0.0	0.7
30.0	0.098	9.7	0.7	0.018	5.1	0.0	0.7
45.0	0.095	9.5	0.6	0.020	5.1	0.0	0.6
60.0	0.094	9.3	0.6	0.021	5.1	0.0	0.6
75.0	0.091	9.1	0.6	0.023	5.1	0.0	0.6
90.0	0.090	9.0	0.6	0.024	5.2	0.0	0.6
105.0	0.087	8.8	0.5	0.024	5.2	0.0	0.5
120.0	0.088	8.7	0.5	0.025	5.2	0.0	0.6
135.0	0.088	8.7	0.5	0.025	5.2	0.0	0.6
150.0	0.089	8.8	0.6	0.024	5.2	0.0	0.6
165.0	0.090	8.9	0.6	0.024	5.2	0.0	0.6
180.0	0.092	9.0	0.6	0.023	5.2	0.0	0.6
195.0	0.094	9.2	0.6	0.021	5.2	0.0	0.7
210.0	0.096	9.4	0.7	0.020	5.2	0.0	0.7
225.0	0.098	9.6	0.7	0.018	5.3	0.0	0.7
240.0	0.100	9.8	0.7	0.016	5.3	0.0	0.7
255.0	0.101	10.0	0.7	0.015	5.3	0.0	0.7

270.0	0.104	10.2	0.8	0.013	5.3	0.0	0.8
285.0	0.104	10.3	0.8	0.012	5.3	0.0	0.8
300.0	0.106	10.3	0.8	0.011	5.2	0.0	0.8
315.0	0.105	10.3	0.8	0.011	5.2	0.0	0.8
330.0	0.105	10.3	0.8	0.012	5.1	0.0	0.8
345.0	0.103	10.2	0.7	0.013	5.1	0.0	0.7

Motion Sickness Incidence at Seakeeping Position

Position label : Seakeeping position

Ship	*** Vertical Motion ***		*** Max Sickness ***		*** Sickness at Time ***
heading	RMS acc	Tz	Max MSI	t(Max MSI)	MSI(t=0.25days)
(deg)	(g)	(s)	(%)	(days)	(%)
0.0	0.095	9.3	30.8	0.48	29.6
15.0	0.106	8.8	36.3	0.45	35.4
30.0	0.118	8.3	41.2	0.42	40.5
45.0	0.128	8.0	45.4	0.40	44.8
60.0	0.138	7.7	48.8	0.38	48.3
75.0	0.147	7.5	51.4	0.36	51.0
90.0	0.153	7.4	53.3	0.35	53.0
105.0	0.158	7.3	54.6	0.34	54.3
120.0	0.160	7.3	55.2	0.34	55.0
135.0	0.161	7.3	55.3	0.33	55.0
150.0	0.159	7.3	54.8	0.34	54.6
165.0	0.155	7.4	53.8	0.34	53.5
180.0	0.149	7.5	52.2	0.35	51.8
195.0	0.142	7.6	49.9	0.37	49.5
210.0	0.133	7.9	46.9	0.39	46.4
225.0	0.122	8.1	43.2	0.41	42.5
240.0	0.111	8.5	38.7	0.43	37.9
255.0	0.100	9.0	33.6	0.46	32.6
270.0	0.090	9.5	28.4	0.49	27.1
285.0	0.081	10.0	23.4	0.52	21.9
300.0	0.075	10.5	20.0	0.54	18.4
315.0	0.074	10.6	19.3	0.54	17.7

330.0	0.078	10.4	21.2	0.53	19.7
345.0	0.086	9.9	25.8	0.69	24.1

Wetness Calculations for Position Above Waterline

Wetness probability is given as probability per wave encounter.

Position label : Seakeeping position

Elevation relative to calm waterline : 7.800 m

Ship heading	Relative vertical motion			*** Wetness ***	
	RMS disp	Tz	RMS vel	P(wet)	Rate
(deg)	(m)	(s)	(m/s)	(per enc)	(/hour)
0.0	0.885	5.8	0.964	0.000000	0.000
15.0	0.957	5.5	1.095	0.000000	0.000
30.0	1.029	5.3	1.226	0.000000	0.000
45.0	1.107	5.2	1.351	0.000000	0.000
60.0	1.177	5.1	1.462	0.000000	0.000
75.0	1.243	5.0	1.558	0.000000	0.000
90.0	1.294	5.0	1.632	0.000000	0.000
105.0	1.332	5.0	1.682	0.000000	0.000
120.0	1.355	5.0	1.709	0.000000	0.000
135.0	1.364	5.0	1.712	0.000000	0.000
150.0	1.356	5.0	1.691	0.000000	0.000
165.0	1.334	5.1	1.646	0.000000	0.000
180.0	1.297	5.2	1.579	0.000000	0.000
195.0	1.247	5.3	1.492	0.000000	0.000
210.0	1.186	5.4	1.386	0.000000	0.000
225.0	1.118	5.5	1.268	0.000000	0.000
240.0	1.043	5.8	1.139	0.000000	0.000
255.0	0.969	6.0	1.011	0.000000	0.000
270.0	0.899	6.4	0.888	0.000000	0.000
285.0	0.843	6.7	0.788	0.000000	0.000
300.0	0.798	7.0	0.718	0.000000	0.000
315.0	0.784	7.0	0.708	0.000000	0.000
330.0	0.791	6.6	0.752	0.000000	0.000

345.0	0.831	6.2	0.846	0.000000	0.000

Annex F: Files for Motions in an Earth-Fixed Seaway with SM3DSeakeepSeawayFromRaos3

F.1 Format of Input File for SM3DSeakeepSeawayFromRaos3

Record (1), Beginning Record

"begin SM3DSeakeepSeawayFromRaos3"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

noteText (character string)

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"end note" (1 character string with 2 words)

Record (4), Ship Dimensions

“shipDimensions”, lpp, stationAP, distanceFPCG, draftBlMid trimBlStern, shipKG (1 character string, 6 floats)

“shipDimensions”	Record tag.
lpp	Ship length between perpendiculars.
stationAP	Station number for aft perpendicular (typically 20.0).
distanceFPCG	Distance from fore perpendicular to longitudinal centre of gravity (LCG) (m).
draftBlMid	Draft of baseline at midships (m).
trimBlStern	Trim of baseline by stern (m).
shipKG	Height of centre of gravity above baseline (m).

Record (5), Name of File with Motion Response Amplitude Operations

“moDefRaoDBFileName”, moDefRaoDBFileName (2 character strings)

“moDefRaoDBFileName”	Record tag.
moDefRaoDBFileName	Name of file with ship motion and appendage deflection response amplitude operators. This file is typically built using application SM3DSeakeepRegular3 or SM3DSeakeepRandom3.

Record (6a), Ship Speed Range in m/s

One of Records (6a) to (6f) must be given.

“speedRange”, speedMin, speedMax, speedInc (1 character string, 3 floats)

“speedRange”	Record tag.
speedMin	Minimum ship speed (m/s).
speedMax	Maximum ship speed (m/s).
speedInc	Increment for ship speed (m/s).

Record (6b), Ship Speeds in m/s

One of Records (6a) to (6f) must be given.

"speeds", speeds (1 character string, array of floats)

"speeds"	Record tag.
speeds	Array of ship speeds (m/s).

Record (6c), Ship Speed Range in Knots

One of Records (6a) to (6f) must be given.

"speedKnotsRange", speedKnotsMin, speedKnotsMax, speedKnotsInc (1 character string, 3 floats)

"speedKnotsRange"	Record tag.
speedKnotsMin	Minimum ship speed (knots).
speedKnotsMax	Maximum ship speed (knots).
speedKnotsInc	Increment for ship speed (knots).

Record (6d), Ship Speeds in Knots

One of Records (6a) to (6f) must be given.

"speedsKnots", speedsKnots (1 character string, array of floats)

"speedsKnots"	Record tag.
speedsKnots	Array of ship speeds (knots).

Record (6e), Froude Number Range

One of Records (6a) to (6f) must be given.

"FroudeRange", froudeMin, froudeMax, froudeInc (1 character string, 3 floats)

"FroudeRange"	Record tag.
froudeMin	Minimum Froude number.
froudeMax	Maximum Froude number.
froudeInc	Froude number increment.

Record (6f), Ship Froude Numbers

One of Records (6a) to (6f) must be given.

"Froudes", froudes (1 character string, array of floats)

"Froudes"	Record tag.
froudes	Array of ship Froude numbers.

Record (7a), Range of Ship Headings

One of Records (7a) or (7b) must be given.

"shipHeadingRange", shipHeadingDegMin, shipHeadingDegMax, shipHeadingDegInc (1 character string, 3 floats)

"shipHeadingRange"	Record tag.
shipHeadingDegMin	Minimum ship heading (to, deg).
shipHeadingDegMax	Maximum ship heading (to, deg).
shipHeadingDegInc	Increment for ship heading (to, deg).
Note:	The ship heading convention is 0° for the ship heading north, 90° for the ship heading east.

Record (7b), Ship Headings

One of Records (7a) or (7b) must be given.

"shipHeadingsDeg", shipHeadingsDeg (1 character string, array of floats)

"shipHeadingsDeg"	Record tag.
shipHeadingsDeg	Array of ship headings (deg). The ship heading convention is 0° for the ship heading north, 90° for the ship heading east.

Record (8), Seaway Option

“spectrumOption”, spectrumOption (2 character strings)

“spectrumOption”	Record tag.
spectrumOption	Type of seaway.
	UniSpectrum - Unidirectional seaway based on input spectrum.
	CosSpectrum - Directional spectrum describe by a point wave spectrum and cosine-squared spreading function.
	DirSpectrum - Directional seaway with specified directional properties.

Record (9), Beginning of Unidirectional Wave Spectrum

Records (9) to (9d) are required if spectrumOption is set to UniSpectrum in Record (8).

“begin uniSpectrum” (1 character string with 2 words)

Record (9a), Wave Heading

This record is required if seawayOption in Record (8) is set to UniSpectrum.

“waveHeading”, waveHeadingFromDeg (1 character string, 1 float)

“waveHeading”	Record tag.
waveHeadingFromDeg	Wave direction ν (from, degrees). 0° for waves from north, and 90° for waves from east.

Record (9b), Unidirectional Wave Spectrum Option

This record is required if spectrumOption in Record (8) is set to UniSpectrum.

"uniSpectrumOption", uniSpectrumOption (2 character strings)

"uniSpectrumOption"	Record tag.
uniSpectrumOption	Type of unidirectional wave spectrum. Bretschneider - Unidirectional Bretschneider wave spectrum. JONSWAP - Unidirectional JONSWAP wave spectrum. OchiHubble - Unidirectional Ochi and Hubble six parameter wave spectrum. Input - Unidirectional user-input wave spectrum.

Record (9c1), Unidirectional Bretschneider Spectrum Seaway Parameters

This record is required if uniSpectrumOption in Record (9b) is set to Bretschneider.

"BretParam", hs, tp (1 character string, 2 floats)

"BretParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).

Record (9c2), Unidirectional JONSWAP Spectrum Seaway Parameters

This record is required if uniSpectrumOption in Record (9b) is set to JONSWAP.

"JONSWAPParam", hs, tp, peakEnhance (1 character string, 3 floats)

"JONSWAPParam"	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).
peakEnhance	Peak enhancement factor γ. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (9c3), Unidirectional Ochi Hubble Spectrum Parameters

This record is required if uniSpectrumOption in Record (9b) is set to OchiHubble.

"OchiHubbleParam", hs1, freqPeak1, spectralShape1, hs2, freqPeak2, spectralShape2 (1 character string, 6 floats)

"OchiHubbleParam"	Record tag.
hs1	Significant wave height h_{s-1} of wave system 1 (m).
freqPeak1	Peak wave frequency ω_{p-1} of wave system 1 (rad/s).
spectralShape1	Spectral shape factor λ_1 of wave system 1.
hs2	Significant wave height h_{s-2} of wave system 2 (m).
freqPeak2	Peak wave frequency ω_{p-2} of wave system 2 (rad/s).
spectralShape2	Spectral shape factor λ_2 of wave system 2.

Record (9c4), Unidirectional Input Spectrum Wave Frequencies

This record is required if uniSpectrumOption in Record (9b) is set to Input.

"inputWaveFreqs", inputWaveFreqs (1 character string, array of floats)

"inputWaveFreqs"	Record tag.
inputWaveFreqs	Wave frequencies ω_I for input energy densities (rad/s).

Record (9c5), Unidirectional Input Spectrum Energy Densities

This record is required if uniSpectrumOption in Record (9b) is set to Input

"inputEnergyDensities", inputEnergyDensities (1 character string, array of floats)

"inputEnergyDensities"	Record tag.
inputEnergyDensities	Wave spectrum energy densities $S_{\omega_I}(\omega_I)$ corresponding to wave frequencies of Record (9c4).

Record (9d), End of Unidirectional Wave Spectrum

This record is required if spectrumOption is set to UniSpectrum in Record (8).

"end uniSpectrum" (1 character string with 2 words)

Record (10), Beginning of Cosine-squared Spreading Wave Spectrum

Records (10) to (10d) are required if spectrumOption is set to CosSpectrum in Record (8).

"begin cosSpectrum" (1 character string with 2 words)

Record (10a), Mean Wave Heading

This record is required if seawayOption in Record (8) is set to CosSpectrum.

"waveHeadingMean", waveHeadingMeanDeg (1 character string, 1 float)

"waveHeadingMean"	Record tag.
waveHeadingMeanDeg	Mean wave direction ν (from, degrees). 0° for waves from north, and 90° for waves from east.

Record (10b), Wave Spreading Angle

This record is required if spectrumOption in Record (8) is set to CosSpectrum.

"spreadAngle", spreadAngleDeg (1 character string, 1 float)

"spreadAngle"	Record tag.
spreadAngleDeg	Directional spreading angle (deg).

Record (10c), Cosine-Squared Wave Spectrum Option

This record is required if spectrumOption in Record (8) is set to CosSpectrum.

"cosSpectrumOption", cosSpectrumOption (2 character strings)

"cosSpectrumOption"	Record tag.
cosSpectrumOption	Type of wave spectrum with cosine-squared directional spreading: CosBretschneider - Bretschneider wave spectrum with cosine-squared directional spreading. CosJONSWAP - JONSWAP wave spectrum with cosine-squared directional spreading.

Record (10c1), Cosine-squared Bretschneider Spectrum Parameters

This record is required if cosSpectrumOption in Record (10c) is set to CosBretschneider.

“BretParam”, hs, tp (1 character string, 2 floats)

“BretParam”	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).

Record (10c2), Cosine-squared JONSWAP Spectrum Seaway Parameters

This record is required if cosSpectrumOption in Record (10c) is set to CosJONSWAP.

“JONSWAPParam”, hs, tp, peakEnhance (1 character string, 3 floats)

“JONSWAPParam”	Record tag.
hs	Significant wave height H_s (m).
tp	Peak wave period T_p (s).
peakEnhance	Peak enhancement parameter γ. This factor can be set to 3.3 to match a 2 parameter JONSWAP spectrum.

Record (10d), End of Cosine-squared Spreading Wave Spectrum

This record is required if spectrumOption is set to CosSpectrum in Record (8).

“end cosSpectrum” (1 character string with 2 words)

Record (11), Beginning of Directional Wave Spectrum

Records (11) to (11d) are required if spectrumOption is set to DirSpectrum in Record (8).

“begin dirSpectrum” (1 character string with 2 words)

Record (11a), Directional Wave Spectrum Option

This record is required if spectrumOption in Record (8) is set to DirSpectrum.

"dirSpectrumOption", dirSpectrumOption (2 character strings)

"dirSpectrumOption"	Record tag.
dirSpectrumOption	Type of unidirectional wave spectrum: TenParameter - Ten parameter spectrum from Hogben and Cobb [23]. EndecoWaveBuoy - Directional spectrum from Endeco wave buoy. InputDir - Input directional spectrum.

Record (11a1), Ten Parameter Spectrum Parameters

This record is required if dirSpectrumOption in Record (11a) is set to TenParameter.

"tenParamParam", hs1, freqPeak1, spectralShape1, waveHeadingMeanDeg1, dirSpreadExp1, hs2, freqPeak2, spectralShape2, waveHeadingMeanDeg2, dirSpreadExp2 (1 character string, 10 floats)

"tenParamParam"	Record tag.
hs1	Significant wave height h_{s-1} of wave system 1 (m).
freqPeak1	Peak wave frequency ω_{p-1} of wave system 1 (rad/s).
spectralShape1	Spectral shape factor λ_1 of wave system 1.
waveHeadingMeanDeg1	Principle wave direction $\overline{\nu_1}$ (from, degrees) of wave system 1. 0° for waves from north, and 90° for waves from east.
dirSpreadExp1	Directional spreading exponent P_1 of wave system 1.
hs2	Significant wave height h_{s-2} of wave system 2 (m).
freqPeak2	Peak wave frequency ω_{p-2} of wave system 2 (rad/s).
spectralShape2	Spectral shape factor λ_2 of wave system 2.
waveHeadingMeanDeg2	Principle wave direction $\overline{\nu_2}$ (from, degrees) of wave system 2. 0° for waves from north, and 90° for waves from east.
dirSpreadExp2	Directional spreading exponent P_2 of wave system 2.

Record (11b), Endeco Wave Buoy Spectrum File Name

This record is required if spectrumOption in Record (8) is set to EndecoWaveBuoy.

"EndecoSpectrumFileName", EndecoSpectrumFileName (2 character strings)

"EndecoSpectrumFileName"	Record tag.
EndecoSpectrumFileName	File name of directional wave spectrum file produced by Endeco 956 or 1156 wave buoy. The file name will typically have the extension ".std".

Record (11c), Input Directional Wave Spectrum File Name

This record is required if spectrumOption in Record (8) is set to inputDir.

"inputDirSpectrumFileName", inputDirSpectrumFileName (2 character strings)

"inputDirSpectrumFileName"	Record tag.
inputDirSpectrumFileName	Input directional wave spectrum file name. The format of the directional wave spectrum file is given in Annex A.2.

Record (11d), End of Directional Wave Spectrum

This record is required if spectrumOption is set to DirSpectrum in Record (8).

"end dirSpectrum" (1 character string with 2 words)

Record (12a), Range of Incident Wave Frequencies for Integration of Ship Motion Spectrum

One of Records (12a) or (12b) must be given.

"waveFreqRange", waveFreqMin, waveFreqMax, waveFreqInc (1 character string, 3 floats)

"waveFreqRange"	Record tag.
waveFreqMin	Minimum incident wave frequency (rad/s).
waveFreqMax	Maximum incident wave frequency (rad/s).
waveFreqInc	Increment for incident wave frequency (rad/s).

Record (12b), Incident Wave Frequencies for Integration of Ship Motion Spectrum

One of Records (12a) or (12b) must be given.

“waveFreqs”, waveFreqs (1 character string, array of floats)

“waveFreqs”	Record tag.
waveFreqs	Array of increasing incident wave frequencies (rad/s).

Record (13a), Wave Direction Range for Integration of Ship Motion Spectrum

If spectrumOption in Record (8) is set to CosSpectrum or DirSpectrum, then one of Records (13a) or (13b) must be given.

“waveDirFromRange”, waveDirFromDegMin, waveDirFromDegMax, waveDirFromDegInc (1 character string, 3 floats)

“waveDirFromRange”	Record tag.
waveDirFromDegMin	Minimum wave direction (deg).
waveDirFromDegMax	Maximum wave direction (deg).
waveDirFromDegInc	Wave direction increment (deg).
Note:	Wave directions are given using a convention of 0° for waves from north, 90° for waves from east.

Record (13b), Wave Directions Integration of Ship Motion Spectrum

If spectrumOption in Record (8) is set to CosSpectrum or DirSpectrum, then one of Records (13a) or (13b) must be given.

“waveDirsFrom”, waveDirsFromDeg (1 character string, array of floats)

“waveDirsFrom”	Record tag.
waveDirsFromDeg	Wave directions for integration of ship motion spectrum. Wave directions are given using a convention of 0° for waves from north, 90° for waves from east.

Record (14), Beginning of Steady Forward Speed Sinkage and Trim Data

Records (14) to (14b) can optionally be used to give ship sinkage and trim data.

“begin steadySinkageTrim” (1 character string with 2 words)

Record (14a), Sinkage and Trim for Ship Speed

This record is repeated once for every ship speed with sinkage and trim data, with increasing ship speeds.

"speedSinkageTrim", speedSinkageTrim, heaveSteady, pitchSteadyDeg (1 character string, 3 floats)

"speedSinkageTrim"	Record tag.
speedSinkageTrim	Speed for which sinkage and trim values are given (m/s)
heaveSteady	Heave at steady speed (m, + up).
pitchSteadyDeg	Pitch at steady speed (deg, + bow down).

Record (14b), End of Steady Sinkage and Trim Data

This record is required if Records (14) and (14a) are included.

"end steadySinkageTrim" (1 character string with 2 words)

Record (15), Beginning of Steady Forward Speed Wave Elevation Data

Records (15) to (15d) can optionally be used to give ship steady wave profile data data.

"begin steadyWaveProfile" (1 character string with 2 words)

Record (15a), Stations for Steady Wave Elevation Data

This record is required if steady wave elevation data are being given.

"stationsSteadyWaveProfile", stationsSteadyWaveProfile (1 character string, nStationSteadyWaveProfile floats)

"stationsSteadyWaveProfile"	Record tag.
stationsSteadyWaveProfile	Ship stations for steady wave elevation data.

Record (15b), Speeds in m/s for Steady Wave Elevation Data

This record is required if steady wave elevation data are being given.

"speedsSteadyWaveProfile", speedsSteadyWaveProfile (1 character string, nSpeedSteadyWaveProfile floats)

"speedsSteadyWaveProfile"	Record tag.
speedsSteadyWaveProfile	Ship speeds for steady wave elevation data (m/s).

Record (15c), Steady Wave Elevation Profile Data

This record must be given for each station with steady wave elevation data.

"stationSteadyWaveElevs", stationSteadyWave, waveElevsSteady (1 character string, 1 + nSpeedSteadyWaveProfile floats)

"stationSteadyWaveElevs"	Record tag.
stationSteadyWave	Station number for input wave elevations. This value must be consistent with values given in Record (15a).
waveElevsSteady	Wave elevations (m) at stationSteadyWave for ship speeds specified in Record (15b).

Record (15d), End of Steady Wave Profile Data

This record is required if Record (15) and subsequent records have been entered.

"end steadyWaveProfile" (1 character string with 2 words)

Record (16), Beginning of Seakeeping Position Data

This record is optional.

"begin seakeepPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (16a) to (16f6) giving seakeeping position parameters. Record (16g) must follow at the end of all seakeeping position data.

Record (16a), Seakeeping Position Label

This record is required if a seakeeping position is being specified.

"labelPos", labelPos (2 character strings)

"labelPos"	Record tag.
labelPos	Label for seakeeping position. This can include spaces.

Record (16b), Seakeeping Position Location

This record is required if a seakeeping position is being specified.

"locationPos", stationPos, yPos, zBlPos (1 character string, 3 floats)

"locationPos"	Record tag.
stationPos	Station for seakeeping position. Station 0 is at the fore perpendicular.
yPos	Lateral coordinate (+ port) relative to ship centreline (m).
zBlPos	Vertical coordinate (+ up) relative to ship baseline (m).

Record (16c), Option for Radiation and Diffraction when Evaluating Relative Vertical Motion

This record is optional if a seakeeping position is being specified.

"relMoRadDifOption" relMoRadDifOption (2 character strings)

"relMoRadDifOption"	Record tag.
relMoRadDifOption	Option for including radiation and diffraction in relative vertical motion: NoRadDif - Wave radiation and diffraction are not considered when evaluating relative wave motion (default).

Record (16d), Option for Including the Steady Wave Due to Ship Forward Speed when Evaluating Wetness or Emergence Events

This record is optional if a seakeeping position is being specified.

"relWaveElevSteadyOption", relWaveElevSteadyOption (2 character strings)

"relWaveElevSteadyOption"	Record tag.
relWaveElevSteadyOption	Option for including the influence of the steady wave field due to ship forward speed when evaluating distance from the waterline in calm water:
	NoSteadyWave - The steady wave due to ship forward speed is not included (default). This option must be used if no steady wave data are provided in Records (14) to (15d).
	SinkageTrimOnly - The ship sinkage and trim due to ship forward speed are included when evaluated vertical position relative to the calm waterline. Sinkage and trim values specified in input Records (14) to (14b).
	SteadyWaveElev - The steady wave elevation is evaluated based on steady wave profile specified in Records (15) to (15d). Sinkage and trim from Records (14) to (14b) are included.

Record (16e), Option for Motion-Induced Interruptions

This record is required if a seakeeping position is being specified.

"miiOption", miiOption (2 character strings)

"miiOption"	Record tag.
miiOption	Option for motion-induced interruption computations:
	Mii - Motion-induced interruption computations are performed.
	NoMii - No motion-induced interruption computations are performed.

Record (16e1), Parameters for Motion-Induced Interruptions

This record is required if miiOption is set to mii in Record (16e).

"miiParam", tipCoLat, tipCoLong, durationMii (1 character strings, 3 floats)

"miiParam"	Record tag.
tipCoLat	Lateral tipping coefficient. A value of 0.25 is typically used for humans facing forward.
tipCoLong	Longitudinal tipping coefficient. A value of 0.17 is typically used for humans facing forward.
durationMii	Duration for computing incidence of motion-induced interruptions (s). A value of 60 s is typically used.
Note:	For sliding calculations, the user should set tipCoLat and tipCoLong equal to the static coefficient of friction.

Record (16f), Option for Slamming, Deck Wetness, or Emergence Computations

This record is required if a seakeeping position is being specified.

"slamWetEmergeOption", slamWetEmergeOption (2 character strings)

"slamWetEmergeOption"	Record tag.
slamWetEmergeOption	Option for slamming, deck wetness, or emergence computations: NoSlamWetEmerge - No slamming, deck wetness, or emergence computations are performed. SlamPressureCoWidth - Slamming calculations are performed using an input slamming form factor and effective pressure width specified in Record (16f2). SlamWedge - Slamming calculations are performed using wedge dimensions given in Record (16f3). SlamOffsets - Slamming calculations are performed using offsets given in Records (16f4), (16f5), and (16f6). WetnessEmerge - Incidence of wetness or emergence calculations are performed, depending on whether the position is above or below the waterline.

Record (16f1), Duration and Exceedence Probability for Slamming, Wetness, or Emergence Statistics

This record is required if slamWetEmergeOption in Record (16f) is set to SlamPressureCoWidth, SlamWedge, SlamOffsets, or WetnessEmerge.

"durationPExceed", durationHours, pExceed (1 character string, 2 floats)

"durationPExceed"	Record tag.
durationHours	Duration for slamming, wetness, or emergence statistics (hours).
pExceed	Exceedence probability for slamming, wetness, or emergence statistics.

Record (16f2), Slamming Pressure Coefficient and Effective Pressure Width

This record is required if slamWetEmergeOption in Record (16f) is set to SlamPressureCoWidth.

"slamPressureCoWidth", slamPressureCo, slamForceWidth (1 character string, 2 floats)

"slamPressureCoWidth"	Record tag.
slamPressureCo	Slamming pressure coefficient.
slamForceWidth	Effective slamming force width (m).

Record (16f3), Wedge Geometry for Slamming Calculations

This record is required if slamWetEmergeOption in Record (16f) is set to SlamWedge.

"slamWedge", deadRiseDeg, slamForceHeight (1 character string, 2 floats)

"slamWedge"	Record tag.
deadRiseDeg	Hull deadrise angle at keel (degrees). This value must be greater than 0 degrees. For deadrise angles less than 5 degrees, this approach can be inaccurate, and is recommended that either the slamForm or slamOffsets option be used instead for slamWetEmergeOption in Record (16f).
slamForceHeight	Height above the keel at which slamming pressure goes to zero (typically taken as $0.1T_x$, where T_x is the sectional draft).

Record (16f4), Elevation Above Baseline for Zero Slamming Pressure

This record is required if slamWetEmergeOption in Record (16f) is set to SlamOffsets.

"zBlZeroSlamPres", zBlZeroSlamPres (1 character string, 1 float)

"zBlZeroSlamPres"	Record tag.
zBlZeroSlamPres	Elevation above baseline at which slamming pressure goes to zero (m). This value is typically assumed to be at a height of $0.1T_x$ above the baseline, where T_x is sectional draft.

Record (16f5), Y Offsets for Performing Slamming Calculations

This record is required if slamWetEmergeOption in Record (16f) is set to SlamOffsets.

"yOffsetsSlam", yOffsetsSlam (1 character string, array of floats)

"yOffsetsSlam"	Record tag.
yOffsetsSlam	Horizontal offsets for points going from keel to at least zBlZeroSlamPres (Record (16f4)) above the baseline (m).

Record (16f6), Z Offsets for Performing Slamming Calculations

This record is required if slamWetEmergeOption in Record (16f) is set to SlamOffsets.

"zBlOffsetsSlam", zBlOffsetsSlam (1 character string, array of floats)

"zBlOffsetsSlam"	Record tag.
zBlOffsetsSlam	Vertical offsets for points going from keel to at least zBlZeroSlamPres (Record (16f4)) above the baseline (m).

Record (16g), End of Seakeeping Position Data

This record is required if Record (16) is present.

"end seakeepPositions" (1 character string with 2 words)

Record (17), End Record

"end SM3DSeakeepSeawayFromRaos3"(1 character string with 2 words)

F.2 Sample Input File for SM3DSeakeepSeawayFromRaos3

```
begin SM3DSeakeepSeawayFromRaos3
label Generic frigate
shipDimensions 120 20 61.7501556572279 4.2 0 6
moDefRaoDBFileName genFrigSeakeepRandomMoDefRaoDB.bin
speedKnotsRange 0 30 10
shipHeadingRange 0 345 15
spectrumOption DirSpectrum
begin dirSpectrum
    dirSpectrumOption TenParameter
    tenParamParam 3 0.6 1 110 1 4 0.4 1 160 1
end dirSpectrum
waveFreqRange 0.2 2 0.05
waveDirFromRange 0 360 5
begin seakeepPositions
labelPos Bridge
    locationPos 3 2 12
    relMoRadDifOption NoRadDif
    relWaveElevSteadyOption NoSteadyWave
    miiOption Mii
    miiParam 0.25 0.17 60
    motionSicknessOption MotionSickness
    tDayMotionSickness 0.25
    slamWetEmergeOption WetnessEmerge
    durationPExceed 1 0.01
end seakeepPositions
end SM3DSeakeepSeawayFromRaos3
```

F.3 Sample Output File for SM3DSeakeepSeawayFromRaos3

```
Program SM3DSeakeepSeawayFromRaos3
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-10-11 1:58:37 PM
Run label:
Generic frigate

**** ECHO OF USER INPUT ****

Ship Dimensions
Length between perpendiculars           :   120.000 m
Station number of aft perpendicular     :    20.000
Distance from fore perpendicular to LCG :    61.750
Draft of baseline at midships           :     4.200 m
Trim of baseline by stern               :     0.000 m
Height of CG above baseline             :     6.000 m

File name with ship motion RAOs :
genFrigSeakeepRandomMoDefRaoDB.bin
Label   : Generic frigate
Created : November-10-11 9:07:44 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.FreqDomain.MotionDeflectRaoDB

Speed range
Minimum   :    0.000 knots
Maximum   :   30.000 knots
Increment :   10.000 knots

Sea direction range
Minimum   :    0.000 deg
Maximum   :  345.000 deg
Increment :   15.000 deg

Seaway
Spectrum type :
Directional spectrum type :
Ten parameter spectrum parameters
Wave system                          1              2
Significant wave height     :     3.000 m         4.000 m
Peak wave frequency         :     0.600 rad/s     0.400 rad/s
Spectral shape factor       :     1.000           1.000
Mean wave direction (from)  :   110.000 deg     160.000 deg
Directional spread exponent :     1.000           1.000

Incident wave frequency range for integration of ship motion spectra
Minimum   :    0.200 rad/s
Maximum   :    2.000 rad/s
```

```
Increment :    0.050 rad/s

Incident wave direction range (from) for integration of ship motion spectra
Minimum   :    0.000 deg
Maximum   :  360.000 deg
Increment :    5.000 deg

Seakeeping Positions

Label              : Bridge
Station            :     3.000
Lateral offset y   :     2.000 m (+ port)
Vertical offset zBl :    12.000 m (+ up, relative to baseline)
Option for including radiation and diffraction for relative motion : NoRadDif
                                                                       (input)
Option for including steady wave due to ship forward speed : NoSteadyWave (input)
Option for motion-induced interruption computations : Mii
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Duration for MII incidence       :      60.0 s
Option for motion sickness computations : MotionSickness
Parameters for motion sickness
Exposure time :     0.250 days
Option for slamming, wetness, or emergence computations : WetnessEmerge
Parameters for slamming, wetness or emergence statistics
Duration               :     1.000 hours
Exceedence probability :  0.010000

**** SEAKEEPING POSITION TRIM CONDITIONS ****

Label           : Bridge
Station         :     3.000
x wrt ship CG   :    43.750 m
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Time of operation                :    60.000 s
Parameters motion sickness
Time for motion sickness               :     0.250 days


**** DIRECTIONAL WAVE SPECTRUM ****

Ten parameter directional wave spectrum
Significant wave height  :     5.000 m
Wave system                         1               2
```

```
Significant wave height        :     3.000 m         4.000 m
Peak wave frequency            :     0.600 rad/s     0.400 rad/s
Spectral shape parameter       :     1.000 deg       1.000 deg
Mean wave direction (from)     :   110.000         160.000
Directional spreading exponent :     1.000           1.000
Significant wave height based on directional wave spectrum area :     4.989 m
```

Wave frequency (rad/s)	Spectral density m2/(rad/s)
0.200	0.000
0.250	0.036
0.300	1.013
0.350	2.889
0.400	3.643
0.450	3.556
0.500	3.323
0.550	3.020
0.600	2.622
0.650	2.184
0.700	1.766
0.750	1.404
0.800	1.107
0.850	0.871
0.900	0.686
0.950	0.543
1.000	0.432
1.050	0.346
1.100	0.279
1.150	0.227
1.200	0.185
1.250	0.153
1.300	0.126
1.350	0.105
1.400	0.088
1.450	0.074
1.500	0.063
1.550	0.054
1.600	0.046
1.650	0.039
1.700	0.034
1.750	0.029
1.800	0.026
1.850	0.022
1.900	0.020
1.950	0.017
2.000	0.015

**** Motions at Ship CG in a Seaway ****

Ship speed : 10.300 m/s (20.000 knots, Froude number 0.300)
Ship heading (to) is in earth-fixed axes.
0 degrees for ship heading north, 90 degrees for ship heading east
RMS Displacements and Zero-crossing Periods

Ship heading	Surge		Sway		Heave		Roll		Pitch		Yaw	
(deg)	(m)	(s)	(m)	(s)	(m)	(s)	(deg)	(s)	(deg)	(s)	(deg)	(s)
0.0	1.95	26.2	0.85	16.2	1.01	11.1	4.92	12.0	1.00	8.9	1.15	16.5
15.0	1.85	25.9	0.82	15.6	1.02	10.6	4.78	11.9	1.04	8.3	1.10	16.2
30.0	1.73	25.5	0.79	15.0	1.04	10.1	4.62	11.7	1.09	7.8	1.04	15.8
45.0	1.59	24.9	0.76	14.3	1.06	9.7	4.45	11.5	1.14	7.4	0.97	15.2
60.0	1.42	24.0	0.73	13.5	1.08	9.3	4.27	11.3	1.18	7.2	0.90	14.6
75.0	1.25	22.9	0.70	12.9	1.10	9.1	4.11	11.1	1.22	7.0	0.83	13.9
90.0	1.07	21.5	0.67	12.3	1.12	8.9	3.95	10.9	1.26	6.8	0.76	13.2
105.0	0.91	19.8	0.65	11.8	1.13	8.7	3.81	10.7	1.29	6.7	0.71	12.6
120.0	0.78	18.1	0.64	11.5	1.14	8.6	3.76	10.6	1.30	6.7	0.67	12.1
135.0	0.70	17.1	0.64	11.5	1.14	8.6	3.77	10.5	1.31	6.7	0.66	12.0
150.0	0.72	17.3	0.64	11.6	1.14	8.6	3.82	10.6	1.30	6.7	0.68	12.2
165.0	0.81	18.7	0.66	11.9	1.14	8.7	3.91	10.7	1.29	6.8	0.73	12.7
180.0	0.95	20.5	0.69	12.5	1.12	8.8	4.04	10.9	1.26	6.9	0.79	13.4
195.0	1.13	22.4	0.72	13.0	1.11	9.0	4.20	11.1	1.23	7.1	0.85	14.1
210.0	1.31	23.8	0.75	13.7	1.09	9.3	4.37	11.3	1.19	7.3	0.92	14.7
225.0	1.49	24.8	0.78	14.4	1.07	9.6	4.55	11.5	1.14	7.6	0.99	15.3
240.0	1.64	25.5	0.82	15.1	1.05	10.0	4.70	11.7	1.10	8.0	1.06	15.8
255.0	1.78	26.0	0.84	15.8	1.03	10.5	4.83	11.9	1.05	8.6	1.12	16.3
270.0	1.89	26.3	0.86	16.3	1.01	11.0	4.98	12.0	1.01	9.2	1.17	16.5
285.0	1.98	26.5	0.88	16.7	1.00	11.5	5.07	12.1	0.98	9.9	1.20	16.7
300.0	2.03	26.6	0.89	17.0	0.99	11.8	5.12	12.1	0.95	10.4	1.22	16.9
315.0	2.06	26.6	0.89	17.0	0.98	12.0	5.13	12.2	0.94	10.6	1.22	16.9
330.0	2.05	26.6	0.88	16.9	0.99	11.9	5.09	12.1	0.95	10.3	1.21	16.9
345.0	2.01	26.5	0.87	16.6	0.99	11.6	5.02	12.1	0.97	9.6	1.19	16.7

Seakeeping at Position on Ship

```
Label           : Bridge
Station         :     3.000
x wrt ship CG   :    43.750 m
y               :     2.000 m
z wrt baseline  :    12.000 m
z wrt ship CG   :     6.000 m
z wrt waterline :     7.800 m
Parameters for motion-induced interruptions
Lateral tipping coefficient      :     0.250
Longitudinal tipping coefficient :     0.170
Time of operation                :    60.000 s
Parameters motion sickness
Time for motion sickness               :     0.250 days
RMS Motions at Seakeeping Position

Position label : Bridge
```

Ship heading	*** Longitudinal ***			*** Lateral ***			*** Vertical ***			** Relative Vertical **		
	Disp	Tz	Acc	Disp	Tz	Acc	Disp	Tz	Acc	Disp	Tz	Vel
(deg)	(m)	(s)	(g)	(m)	(s)	(g)	(m)	(s)	(g)	(m)	(s)	(m/s)
0.0	1.872	26.7	0.013	1.157	16.0	0.031	1.370	9.4	0.094	0.885	5.8	0.961
15.0	1.777	26.5	0.013	1.118	15.5	0.031	1.419	8.9	0.105	0.953	5.5	1.091
30.0	1.657	26.2	0.013	1.070	14.9	0.032	1.475	8.4	0.116	1.027	5.3	1.221
45.0	1.515	25.7	0.013	1.017	14.2	0.033	1.534	8.0	0.126	1.102	5.2	1.344
60.0	1.356	25.1	0.013	0.962	13.5	0.034	1.592	7.8	0.136	1.172	5.1	1.454
75.0	1.184	24.2	0.013	0.906	12.8	0.034	1.645	7.6	0.144	1.234	5.0	1.547
90.0	1.010	23.0	0.013	0.856	12.1	0.035	1.690	7.4	0.151	1.285	5.0	1.620
105.0	0.846	21.6	0.013	0.817	11.5	0.036	1.724	7.4	0.156	1.321	5.0	1.669
120.0	0.715	20.0	0.013	0.790	11.1	0.036	1.747	7.3	0.158	1.344	5.0	1.696
135.0	0.646	19.1	0.013	0.779	11.0	0.036	1.757	7.3	0.159	1.352	5.0	1.699
150.0	0.663	19.5	0.013	0.788	11.1	0.036	1.753	7.3	0.157	1.345	5.0	1.677
165.0	0.758	20.9	0.013	0.818	11.5	0.036	1.735	7.4	0.153	1.322	5.1	1.632
180.0	0.905	22.6	0.013	0.861	12.0	0.035	1.705	7.5	0.147	1.285	5.2	1.565
195.0	1.084	24.2	0.013	0.909	12.7	0.034	1.665	7.7	0.140	1.235	5.3	1.478
210.0	1.264	25.3	0.013	0.962	13.4	0.034	1.615	7.9	0.130	1.175	5.4	1.373
225.0	1.434	26.0	0.013	1.018	14.1	0.033	1.559	8.2	0.120	1.106	5.5	1.254

240.0	1.587	26.4	0.013	1.072	14.9	0.032	1.500	8.6	0.109	1.033	5.8	1.126
255.0	1.719	26.7	0.013	1.120	15.5	0.031	1.442	9.0	0.098	0.959	6.1	0.996
270.0	1.827	26.9	0.013	1.158	16.0	0.030	1.390	9.6	0.088	0.892	6.4	0.875
285.0	1.908	27.0	0.013	1.186	16.4	0.030	1.347	10.1	0.079	0.835	6.8	0.774
300.0	1.961	27.0	0.013	1.204	16.6	0.029	1.317	10.6	0.074	0.795	7.0	0.711
315.0	1.984	27.0	0.013	1.210	16.7	0.029	1.304	10.7	0.073	0.781	7.0	0.702
330.0	1.976	27.0	0.013	1.204	16.6	0.030	1.309	10.5	0.076	0.792	6.6	0.750
345.0	1.939	26.9	0.013	1.186	16.4	0.030	1.332	10.0	0.084	0.829	6.2	0.843

Forces Relative to Local Axes and Motion-Induced Interruptions

Position label : Bridge

MIIs given as rate for following duration : 60.0 s
Lateral tipping coefficient   :   0.250
Longitudinal tipping coefficient :   0.170

Ship heading	***** Lateral *****			***** Longitudinal *****			Total
	Force estimator		MIIs	Force estimator		MIIs	MIIs
	RMS (g)	Tz (s)		RMS (g)	Tz (s)		
0.0	0.093	9.9	0.4	0.014	5.1	0.0	0.4
15.0	0.091	9.7	0.4	0.016	5.1	0.0	0.4
30.0	0.090	9.5	0.4	0.018	5.1	0.0	0.4
45.0	0.088	9.3	0.4	0.020	5.2	0.0	0.4
60.0	0.086	9.1	0.4	0.021	5.2	0.0	0.4
75.0	0.084	8.9	0.4	0.022	5.2	0.0	0.4
90.0	0.082	8.7	0.3	0.023	5.2	0.0	0.4
105.0	0.081	8.5	0.3	0.024	5.2	0.0	0.4
120.0	0.081	8.5	0.3	0.024	5.2	0.0	0.4
135.0	0.081	8.5	0.3	0.024	5.2	0.0	0.4
150.0	0.081	8.5	0.3	0.024	5.2	0.0	0.4
165.0	0.083	8.6	0.4	0.023	5.2	0.0	0.4
180.0	0.084	8.8	0.4	0.022	5.3	0.0	0.4
195.0	0.086	9.0	0.4	0.021	5.3	0.0	0.4
210.0	0.088	9.2	0.4	0.019	5.3	0.0	0.4

225.0	0.090	9.4	0.4	0.018	5.3	0.0	0.4
240.0	0.091	9.6	0.4	0.016	5.3	0.0	0.4
255.0	0.092	9.9	0.4	0.014	5.3	0.0	0.4
270.0	0.094	10.0	0.4	0.013	5.4	0.0	0.4
285.0	0.095	10.2	0.5	0.011	5.4	0.0	0.5
300.0	0.096	10.2	0.5	0.010	5.3	0.0	0.5
315.0	0.096	10.2	0.5	0.010	5.3	0.0	0.5
330.0	0.095	10.2	0.5	0.011	5.2	0.0	0.5
345.0	0.094	10.1	0.4	0.013	5.2	0.0	0.4

Motion Sickness Incidence at Seakeeping Position

Position label : Bridge

Ship	*** Vertical Motion ***		*** Max Sickness ***		*** Sickness at Time ***
heading	RMS acc	Tz	Max MSI	t(Max MSI)	MSI(t=0.25days)
(deg)	(g)	(s)	(%)	(days)	(%)
0.0	0.094	9.4	29.9	0.48	28.7
15.0	0.105	8.9	35.5	0.45	34.5
30.0	0.116	8.4	40.5	0.42	39.7
45.0	0.126	8.0	44.7	0.40	44.1
60.0	0.136	7.8	48.1	0.38	47.6
75.0	0.144	7.6	50.8	0.36	50.4
90.0	0.151	7.4	52.7	0.35	52.4
105.0	0.156	7.4	54.0	0.34	53.7
120.0	0.158	7.3	54.6	0.34	54.4
135.0	0.159	7.3	54.7	0.34	54.5
150.0	0.157	7.3	54.3	0.34	54.0
165.0	0.153	7.4	53.2	0.35	52.9
180.0	0.147	7.5	51.6	0.36	51.2
195.0	0.140	7.7	49.3	0.37	48.8
210.0	0.130	7.9	46.2	0.39	45.7
225.0	0.120	8.2	42.4	0.41	41.7
240.0	0.109	8.6	37.9	0.44	37.0
255.0	0.098	9.0	32.7	0.47	31.6
270.0	0.088	9.6	27.3	0.50	26.0

285.0	0.079	10.1	22.4	0.52	20.9
300.0	0.074	10.6	19.1	0.54	17.5
315.0	0.073	10.7	18.3	0.55	16.7
330.0	0.076	10.5	20.3	0.54	18.7
345.0	0.084	10.0	24.5	0.51	23.1

Wetness Calculations for Position Above Waterline

Wetness probability is given as probability per wave encounter.

Position label : Bridge

Elevation relative to calm waterline : 7.800 m

Ship heading	Relative vertical motion			*** Wetness ***	
	RMS disp	Tz	RMS vel	P(wet)	Rate
(deg)	(m)	(s)	(m/s)	(per enc)	(/hour)
0.0	0.885	5.8	0.961	0.000000	0.000
15.0	0.953	5.5	1.091	0.000000	0.000
30.0	1.027	5.3	1.221	0.000000	0.000
45.0	1.102	5.2	1.344	0.000000	0.000
60.0	1.172	5.1	1.454	0.000000	0.000
75.0	1.234	5.0	1.547	0.000000	0.000
90.0	1.285	5.0	1.620	0.000000	0.000
105.0	1.321	5.0	1.669	0.000000	0.000
120.0	1.344	5.0	1.696	0.000000	0.000
135.0	1.352	5.0	1.699	0.000000	0.000
150.0	1.345	5.0	1.677	0.000000	0.000
165.0	1.322	5.1	1.632	0.000000	0.000
180.0	1.285	5.2	1.565	0.000000	0.000
195.0	1.235	5.3	1.478	0.000000	0.000
210.0	1.175	5.4	1.373	0.000000	0.000
225.0	1.106	5.5	1.254	0.000000	0.000
240.0	1.033	5.8	1.126	0.000000	0.000
255.0	0.959	6.1	0.996	0.000000	0.000
270.0	0.892	6.4	0.875	0.000000	0.000
285.0	0.835	6.8	0.774	0.000000	0.000

300.0	0.795	7.0	0.711	0.000000	0.000
315.0	0.781	7.0	0.702	0.000000	0.000
330.0	0.792	6.6	0.750	0.000000	0.000
345.0	0.829	6.2	0.843	0.000000	0.000

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Annex G: Files for Producing Time Series of Ship Motions based on Response Amplitude Operators

G.1 Format of Input File for SM3DTimeSeriesFromRaos3

Record (1), Beginning Record

"begin SM3DTimeSeriesFromRaos3"(1 character string with 2 words)

Record (2), Run Label

"label", label (2 character strings)

"label" Record tag.

label Label for run. This can include spaces.

Record (3), Beginning of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"begin note" (1 character string with 2 words)

Record (3a), Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

noteText (character string)

noteText Text of note. Multiple lines can be entered.

Record (3b), End of Note

Input Records (3) to (3b) can optionally be used together to give a descriptive note regarding input.

"end note" (1 character string with 2 words)

Record (4), Ship Dimensions

"shipDimensions", lpp, stationAP, distanceFPCG, draftBlMid trimBlStern, shipKG (1 character string, 6 floats)

"shipDimensions"	Record tag.
lpp	Ship length between perpendiculars.
stationAP	Station number for aft perpendicular (typically 20.0).
distanceFPCG	Distance from fore perpendicular to longitudinal centre of gravity (LCG) (m).
draftBlMid	Draft of baseline at midships (m).
trimBlStern	Trim of baseline by stern (m).
shipKG	Height of centre of gravity above baseline (m).

Record (5), Name of File with Motion Response Amplitude Operations

"moDefRaoDBFileName", moDefRaoDBFileName (2 character strings)

"moDefRaoDBFileName"	Record tag.
moDefRaoDBFileName	Name of file with ship motion and appendage deflection response amplitude operators. This file is typically built using application SM3DSeakeepRegular3 or SM3DSeakeepRandom3.

Record (6), Fixed Seaway XML File Name

"fixedSeawayFileName", fixedSeawayFileName (2 character strings)

"fixedSeawayFileName"	Record tag.
fixedSeawayFileName	Name of XML file with seaway in earth-fixed axes. This file is typically built using application SM3DBuildSeaway3.

Record (6a), Motion Axes Output Option

"motionAxesOutputOption", motionAxesOutputOption (2 character strings)

"motionAxesOutputOption"	Record tag.
motionAxesOutputOption	TransEarth - Output values are given in translating earth axes. For seakeeping positions, values are given relative to their position when the ship is moving at speed in calm water.
	EarthFixed - Output values are given in earth-fixed axes.

Record (7), Output Ship Motion Time Interval and Options

"outTimeSeries", outDispOption, outVelOption, outAccOption (4 character strings)

"outTimeSeries"	Record tag.
outDispOption	Option for giving output ship displacements:
	Disp - Output displacements are given.
	NoDisp - No output displacements are given.
outVelOption	Option for giving output ship velocities:
	Vel - Output velocities are given.
	NoVel - No output velocities are given.
outAccOption	Option for giving output ship accelerations:
	Acc - Output accelerations are given.
	NoAcc - No output accelerations are given.

Record (8), Beginning of Seakeeping Position Data

This record is optional.

"begin seakeepPositions" (1 character string with 2 words)

Note: If this record is entered, then it can be followed by an arbitrary number of repetitions of Records (8a) to (8c) giving seakeeping position parameters. Record (8d) must follow at the end of all seakeeping position data.

Record (8a), Seakeeping Position Label

This record is required if a seakeeping position is being specified.

"labelPos", labelPos (2 character strings)

"labelPos"	Record tag.
labelPos	Label for seakeeping position. This can include spaces.

Record (8b), Seakeeping Position Location

This record is required if a seakeeping position is being specified.

"locationPos", stationPos, yPos, zBlPos (1 character string, 3 floats)

"locationPos"	Record tag.
stationPos	Station for seakeeping position. Station 0 is at the fore perpendicular.
yPos	Lateral coordinate (+ port) relative to ship centreline (m).
zBlPos	Vertical coordinate (+ up) relative to ship baseline (m).

Record (8c), Seakeeping Position Output Options

This record is required if a seakeeping position is being specified.

"posOutputOptions", outDispPosOption, outVelPosOption, outAccPosOption, outRelMotionPosOption (5 character strings)

"posOutputOptions"	Record tag.
outDispPosOption	Disp - Displacements at position are written to output.
	NoDisp - No displacements are written to output.
outVelPosOption	Vel - Velocities at position are written to output.
	NoVel - No velocities are written to output.
outAccPosOption	Acc - Accelerations at position are written to output.
	NoAcc - No accelerations are written to output.
outRelMotionPosOption	RelMotion - Relative vertical displacements and velocities at position are written to output.
	NoRelMotion - No relative vertical displacements or velocities at position are written to output.

Record (8d), End of Seakeeping Position Data

This record is required if Record (8) is present.

"end seakeepPositions" (1 character string with 2 words)

Record (9a), Ship Speed

One of Records (9a), (9b), (9c) must be given.

"speed", speed (1 character string, 1 float)

"speed"	Record tag.
speed	Ship speed (m/s).

Record (9b), Ship Speed in Knots

One of Records (9a), (9b), (9c) must be given.

"speedKnots", speedKnots (1 character string, 1 float)

"speedKnots"	Record tag.
speedKnots	Ship speed (knots).

Record (9c), Ship Froude Number

One of Records (9a), (9b), (9c) must be given.

"Froude", Froude (1 character string, 1 float)

"Froude"	Record tag.
Froude	Ship Froude number.

Record (10), Ship Heading

"heading", shipHeadingToMeanDeg (1 character string, 1 float)

"heading"	Record tag.
shipHeadingToMeanDeg	Mean ship heading (to, deg). The heading is 0° for the ship heading north, and 90° for the ship heading east.

Record (11), Initial Ship Position

"shipPosition0", xf0, yf0 (1 character string, 2 floats)

"shipPosition0"	Record tag.
xf0	Initial x^f position of ship at time t0 (m).
yf0	Initial y^f position of ship at time t0 (m).

Record (12), Time Parameters

"timeParameters", t0, tEnd, dt (1 character string, 3 floats)

"timeParameters"	Record tag.
t0	Time at start of time series(s).
tEnd	Time at end of time series(s).
dt	Time increment (s).

Record (13), End Record

"end SM3DTimeSeriesFromRaos3"(1 character string with 2 words)

G.2 Sample Input File for SM3DTimeSeriesFromRaos3

```
begin SM3DTimeSeriesFromRaos3
label Generic frigate
shipDimensions 120 20 61.7501556572279 4.2 0 6
moDefRaoDBFileName genFrigSeakeepRandomMoDefRaoDB.bin
fixedSeawayFileName bretSeaState5Seaway.xml
motionAxesOutputOption TransEarth
outTimeSeries Disp NoVel Acc
speedKnots 20
heading 30
shipPosition0 0 0
timeParameters 0 40 0.2
end SM3DTimeSeriesFromRaos3
```

G.3 Sample Output File for SM3DTimeSeriesFromRaos3 (Accelerations Removed)

```
Program SM3DTimeSeriesFromRaos3
ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Time : November-10-11 2:05:19 PM
Run label:
Generic frigate

**** ECHO OF USER INPUT ****

Ship Dimensions
Length between perpendiculars           :   120.000 m
Station number of aft perpendicular     :    20.000
Distance from fore perpendicular to LCG :    61.750
Draft of baseline at midships           :     4.200 m
Trim of baseline by stern               :     0.000 m
Height of CG above baseline             :     6.000 m

File name with ship motion RAOs :
genFrigSeakeepRandomMoDefRaoDB.bin
Label   : Generic frigate
Created : November-10-11 9:07:44 AM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.FreqDomain.MotionDeflectRaoDB

File name with seaway in earth-fixed axes :
bretSeaState5Seaway.xml
Label   : Hs = 3.25 m, Tp = 9.7 s, Bretschneider spectrum
Created : November-10-11 2:05:19 PM
Version : ShipMo3D 3.0 Version 3.0 release - 5 October 2011
Class   : ShipMo3D.DeepSeaway.FixedMultiSeaway

Motion axes output option : TransEarth
Options for writing ship motion time series to output file
Displacements        : Disp
Velocities           : NoVel
Accelerations        : Acc

Ship speed :    20.000 knots

Ship heading (to) :    30.000

Initial Ship Position in Earth-fixed Axes
xf0 :     0.000 m
yf0 :     0.000 m

Time Parameters
```

```
Start time     :     0.000 s
End time       :    40.000 s
Time increment :     0.200 s
```

Displacements at Ship CG in Translating Earth Axes
Surge + forward
Sway + port
Heave + up
Roll + port side up
Pitch + bow down
Yaw + bow to port

t (s)	Surge (m)	Sway (m)	Heave (m)	Roll (deg)	Pitch (deg)	Yaw (deg)
0.000	-0.198	-0.162	-0.238	0.664	0.823	0.140
0.200	-0.193	-0.146	-0.345	0.766	0.973	0.178
0.400	-0.182	-0.125	-0.446	0.825	1.109	0.210
0.600	-0.166	-0.099	-0.540	0.831	1.219	0.234
0.800	-0.145	-0.070	-0.624	0.776	1.286	0.248
1.000	-0.121	-0.040	-0.694	0.663	1.297	0.250
1.200	-0.093	-0.009	-0.747	0.497	1.237	0.241
1.400	-0.063	0.022	-0.781	0.291	1.100	0.221
1.600	-0.031	0.051	-0.792	0.065	0.884	0.193
1.800	0.002	0.077	-0.776	-0.164	0.596	0.159
2.000	0.035	0.101	-0.733	-0.376	0.252	0.120
2.200	0.067	0.121	-0.661	-0.555	-0.126	0.080
2.400	0.097	0.137	-0.561	-0.693	-0.512	0.039
2.600	0.124	0.148	-0.435	-0.791	-0.880	0.000
2.800	0.148	0.154	-0.288	-0.853	-1.204	-0.035
3.000	0.169	0.156	-0.127	-0.889	-1.464	-0.066
3.200	0.185	0.153	0.040	-0.902	-1.643	-0.091
3.400	0.197	0.146	0.207	-0.893	-1.729	-0.108
3.600	0.203	0.136	0.363	-0.862	-1.719	-0.120
3.800	0.205	0.125	0.501	-0.809	-1.616	-0.125
4.000	0.200	0.111	0.614	-0.737	-1.433	-0.126
4.200	0.190	0.097	0.696	-0.649	-1.187	-0.124
4.400	0.175	0.080	0.745	-0.548	-0.901	-0.119
4.600	0.154	0.063	0.759	-0.438	-0.600	-0.115
4.800	0.129	0.044	0.740	-0.322	-0.304	-0.111
5.000	0.099	0.025	0.694	-0.204	-0.032	-0.110
5.200	0.067	0.004	0.624	-0.087	0.201	-0.112

5.400	0.033	-0.018	0.539	0.024	0.388	-0.115
5.600	-0.002	-0.040	0.445	0.128	0.525	-0.120
5.800	-0.036	-0.061	0.348	0.224	0.614	-0.124
6.000	-0.068	-0.082	0.252	0.313	0.661	-0.125
6.200	-0.096	-0.101	0.162	0.395	0.673	-0.121
6.400	-0.120	-0.117	0.079	0.473	0.662	-0.109
6.600	-0.138	-0.129	0.004	0.551	0.640	-0.088
6.800	-0.151	-0.135	-0.065	0.625	0.621	-0.055
7.000	-0.157	-0.136	-0.129	0.693	0.613	-0.014
7.200	-0.157	-0.130	-0.190	0.748	0.619	0.034
7.400	-0.152	-0.120	-0.251	0.784	0.636	0.082
7.600	-0.142	-0.105	-0.312	0.799	0.655	0.127
7.800	-0.130	-0.088	-0.372	0.793	0.671	0.165
8.000	-0.115	-0.067	-0.428	0.768	0.678	0.194
8.200	-0.097	-0.046	-0.477	0.723	0.671	0.212
8.400	-0.078	-0.023	-0.514	0.658	0.645	0.220
8.600	-0.058	0.000	-0.536	0.576	0.593	0.219
8.800	-0.036	0.022	-0.541	0.480	0.509	0.209
9.000	-0.015	0.042	-0.526	0.373	0.392	0.190
9.200	0.006	0.061	-0.491	0.256	0.243	0.162
9.400	0.025	0.076	-0.434	0.126	0.068	0.124
9.600	0.043	0.088	-0.357	-0.018	-0.124	0.079
9.800	0.059	0.095	-0.261	-0.173	-0.325	0.029
10.000	0.072	0.098	-0.151	-0.333	-0.525	-0.023
10.200	0.083	0.097	-0.031	-0.495	-0.715	-0.071
10.400	0.091	0.091	0.092	-0.653	-0.885	-0.113
10.600	0.098	0.082	0.212	-0.802	-1.025	-0.145
10.800	0.101	0.069	0.321	-0.932	-1.123	-0.166
11.000	0.102	0.056	0.416	-1.024	-1.171	-0.174
11.200	0.101	0.042	0.489	-1.058	-1.162	-0.170
11.400	0.096	0.030	0.539	-1.022	-1.093	-0.155
11.600	0.089	0.018	0.561	-0.922	-0.965	-0.130
11.800	0.078	0.008	0.556	-0.774	-0.786	-0.099
12.000	0.065	-0.002	0.524	-0.600	-0.566	-0.065
12.200	0.050	-0.012	0.468	-0.417	-0.317	-0.032
12.400	0.033	-0.020	0.393	-0.230	-0.053	0.000

12.600	0.015	-0.027	0.305	-0.044	0.214	0.026
12.800	-0.004	-0.031	0.209	0.137	0.468	0.046
13.000	-0.022	-0.033	0.112	0.303	0.694	0.059
13.200	-0.039	-0.035	0.020	0.440	0.876	0.063
13.400	-0.055	-0.036	-0.063	0.535	1.001	0.057
13.600	-0.070	-0.038	-0.132	0.577	1.058	0.043
13.800	-0.082	-0.041	-0.184	0.563	1.042	0.022
14.000	-0.093	-0.045	-0.217	0.497	0.953	-0.004
14.200	-0.101	-0.050	-0.231	0.394	0.800	-0.034
14.400	-0.108	-0.056	-0.225	0.275	0.596	-0.065
14.600	-0.112	-0.063	-0.203	0.159	0.356	-0.094
14.800	-0.113	-0.070	-0.167	0.060	0.101	-0.117
15.000	-0.112	-0.077	-0.124	-0.017	-0.149	-0.130
15.200	-0.107	-0.084	-0.078	-0.070	-0.370	-0.129
15.400	-0.101	-0.089	-0.035	-0.097	-0.539	-0.112
15.600	-0.091	-0.092	0.001	-0.097	-0.635	-0.082
15.800	-0.080	-0.092	0.023	-0.066	-0.645	-0.041
16.000	-0.066	-0.088	0.027	-0.005	-0.571	0.007
16.200	-0.050	-0.078	0.009	0.082	-0.421	0.058
16.400	-0.033	-0.063	-0.033	0.185	-0.213	0.111
16.600	-0.016	-0.044	-0.098	0.300	0.037	0.164
16.800	0.002	-0.020	-0.182	0.419	0.310	0.213
17.000	0.020	0.007	-0.279	0.531	0.586	0.256
17.200	0.039	0.038	-0.380	0.621	0.840	0.287
17.400	0.059	0.071	-0.479	0.674	1.044	0.305
17.600	0.080	0.105	-0.568	0.678	1.171	0.308
17.800	0.101	0.137	-0.639	0.628	1.198	0.293
18.000	0.122	0.167	-0.683	0.529	1.118	0.262
18.200	0.142	0.193	-0.693	0.388	0.934	0.217
18.400	0.161	0.215	-0.661	0.211	0.655	0.160
18.600	0.177	0.230	-0.585	0.004	0.299	0.092
18.800	0.191	0.237	-0.465	-0.224	-0.118	0.017
19.000	0.200	0.236	-0.305	-0.460	-0.575	-0.063
19.200	0.206	0.226	-0.109	-0.689	-1.045	-0.143
19.400	0.205	0.206	0.114	-0.899	-1.500	-0.221
19.600	0.199	0.177	0.356	-1.078	-1.904	-0.291

19.800	0.185	0.140	0.606	-1.219	-2.225	-0.348
20.000	0.165	0.096	0.851	-1.310	-2.436	-0.392
20.200	0.137	0.047	1.077	-1.343	-2.517	-0.419
20.400	0.103	-0.005	1.271	-1.308	-2.461	-0.431
20.600	0.063	-0.059	1.418	-1.204	-2.270	-0.426
20.800	0.017	-0.112	1.509	-1.033	-1.952	-0.403
21.000	-0.033	-0.163	1.536	-0.804	-1.520	-0.365
21.200	-0.085	-0.210	1.495	-0.529	-0.987	-0.310
21.400	-0.137	-0.250	1.385	-0.221	-0.377	-0.242
21.600	-0.187	-0.282	1.210	0.104	0.280	-0.164
21.800	-0.233	-0.304	0.972	0.429	0.949	-0.080
22.000	-0.273	-0.316	0.681	0.736	1.590	0.008
22.200	-0.306	-0.318	0.349	1.010	2.167	0.096
22.400	-0.329	-0.308	-0.011	1.243	2.651	0.181
22.600	-0.341	-0.287	-0.381	1.431	3.022	0.259
22.800	-0.343	-0.255	-0.743	1.570	3.261	0.328
23.000	-0.332	-0.214	-1.081	1.654	3.354	0.383
23.200	-0.310	-0.164	-1.379	1.677	3.293	0.424
23.400	-0.276	-0.110	-1.624	1.631	3.079	0.450
23.600	-0.233	-0.053	-1.802	1.512	2.723	0.459
23.800	-0.181	0.006	-1.905	1.323	2.244	0.451
24.000	-0.122	0.063	-1.927	1.074	1.669	0.424
24.200	-0.059	0.118	-1.866	0.782	1.024	0.378
24.400	0.006	0.167	-1.724	0.462	0.338	0.318
24.600	0.070	0.209	-1.509	0.128	-0.360	0.244
24.800	0.131	0.243	-1.230	-0.212	-1.038	0.163
25.000	0.188	0.266	-0.899	-0.550	-1.664	0.076
25.200	0.236	0.279	-0.533	-0.877	-2.212	-0.013
25.400	0.276	0.280	-0.148	-1.180	-2.657	-0.101
25.600	0.305	0.270	0.238	-1.443	-2.985	-0.185
25.800	0.323	0.250	0.607	-1.648	-3.184	-0.259
26.000	0.330	0.222	0.941	-1.781	-3.247	-0.321
26.200	0.325	0.188	1.226	-1.834	-3.172	-0.366
26.400	0.309	0.148	1.449	-1.804	-2.962	-0.391
26.600	0.284	0.107	1.601	-1.695	-2.626	-0.394
26.800	0.251	0.064	1.677	-1.515	-2.179	-0.376

27.000	0.211	0.023	1.673	-1.277	-1.644	-0.338
27.200	0.167	-0.016	1.593	-0.995	-1.047	-0.286
27.400	0.119	-0.052	1.442	-0.686	-0.420	-0.225
27.600	0.069	-0.082	1.230	-0.361	0.207	-0.162
27.800	0.018	-0.107	0.972	-0.035	0.803	-0.099
28.000	-0.031	-0.126	0.681	0.282	1.340	-0.039
28.200	-0.077	-0.139	0.375	0.576	1.795	0.016
28.400	-0.118	-0.147	0.070	0.834	2.149	0.065
28.600	-0.152	-0.148	-0.219	1.047	2.390	0.107
28.800	-0.179	-0.144	-0.479	1.212	2.507	0.140
29.000	-0.198	-0.134	-0.700	1.329	2.502	0.163
29.200	-0.207	-0.120	-0.873	1.402	2.380	0.178
29.400	-0.208	-0.100	-0.993	1.430	2.158	0.186
29.600	-0.200	-0.078	-1.059	1.408	1.856	0.190
29.800	-0.184	-0.053	-1.071	1.334	1.494	0.188
30.000	-0.162	-0.027	-1.033	1.205	1.091	0.180
30.200	-0.134	-0.003	-0.951	1.025	0.664	0.165
30.400	-0.102	0.019	-0.833	0.801	0.229	0.143
30.600	-0.070	0.038	-0.685	0.547	-0.196	0.114
30.800	-0.037	0.054	-0.516	0.280	-0.595	0.081
31.000	-0.007	0.064	-0.332	0.021	-0.948	0.045
31.200	0.020	0.070	-0.141	-0.212	-1.241	0.008
31.400	0.043	0.071	0.048	-0.408	-1.464	-0.028
31.600	0.061	0.068	0.228	-0.563	-1.613	-0.062
31.800	0.073	0.059	0.390	-0.680	-1.686	-0.090
32.000	0.080	0.047	0.528	-0.759	-1.684	-0.112
32.200	0.081	0.033	0.637	-0.797	-1.604	-0.127
32.400	0.076	0.016	0.714	-0.793	-1.448	-0.136
32.600	0.067	-0.001	0.757	-0.751	-1.222	-0.139
32.800	0.053	-0.018	0.765	-0.684	-0.940	-0.138
33.000	0.036	-0.035	0.737	-0.611	-0.623	-0.132
33.200	0.018	-0.052	0.674	-0.544	-0.291	-0.121
33.400	-0.002	-0.068	0.579	-0.486	0.037	-0.104
33.600	-0.021	-0.081	0.458	-0.430	0.346	-0.081
33.800	-0.038	-0.090	0.316	-0.362	0.628	-0.053
34.000	-0.053	-0.093	0.161	-0.273	0.871	-0.019

34.200	-0.065	-0.090	-0.003	-0.159	1.068	0.019
34.400	-0.072	-0.082	-0.168	-0.025	1.208	0.059
34.600	-0.075	-0.069	-0.327	0.119	1.288	0.099
34.800	-0.074	-0.052	-0.472	0.258	1.308	0.136
35.000	-0.069	-0.032	-0.598	0.377	1.269	0.167
35.200	-0.060	-0.010	-0.696	0.464	1.180	0.189
35.400	-0.047	0.012	-0.761	0.510	1.047	0.198
35.600	-0.032	0.033	-0.790	0.511	0.874	0.193
35.800	-0.015	0.052	-0.780	0.469	0.667	0.173
36.000	0.003	0.068	-0.731	0.389	0.431	0.140
36.200	0.021	0.081	-0.648	0.279	0.171	0.098
36.400	0.039	0.089	-0.534	0.150	-0.103	0.051
36.600	0.056	0.094	-0.395	0.017	-0.376	0.004
36.800	0.071	0.096	-0.238	-0.103	-0.632	-0.039
37.000	0.084	0.095	-0.073	-0.199	-0.855	-0.076
37.200	0.096	0.092	0.091	-0.266	-1.035	-0.104
37.400	0.105	0.087	0.243	-0.308	-1.164	-0.124
37.600	0.112	0.081	0.375	-0.327	-1.239	-0.132
37.800	0.116	0.072	0.480	-0.327	-1.254	-0.130
38.000	0.116	0.063	0.556	-0.310	-1.204	-0.120
38.200	0.113	0.052	0.602	-0.279	-1.087	-0.103
38.400	0.106	0.041	0.616	-0.239	-0.911	-0.084
38.600	0.096	0.029	0.602	-0.195	-0.692	-0.065
38.800	0.083	0.017	0.562	-0.147	-0.451	-0.048
39.000	0.066	0.004	0.499	-0.092	-0.210	-0.035
39.200	0.046	-0.009	0.422	-0.026	0.017	-0.026
39.400	0.024	-0.022	0.336	0.053	0.222	-0.021
39.600	0.000	-0.034	0.249	0.140	0.399	-0.020
39.800	-0.024	-0.045	0.166	0.228	0.544	-0.020
40.000	-0.046	-0.055	0.090	0.313	0.652	-0.022

Statistics of displacements at ship CG in translating earth axes

	Mean	Dev	Max	Min	Tz (s)
Surge (m)	0.005	0.140	0.330	-0.343	6.840
Sway (m)	0.005	0.121	0.280	-0.318	6.800
Heave (m)	-0.009	0.725	1.677	-1.927	5.667

Roll (deg)	-0.009	0.757	1.677	-1.834	5.667
Pitch (deg)	-0.010	1.347	3.354	-3.247	5.667
Yaw (deg)	0.004	0.187	0.459	-0.431	5.400

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ShipMo3D Version 3.0 User Manual for Computing Ship Motions in the Time and Frequency Domains

Kevin McTaggart; DRDC Atlantic TM 2011-308; Defence R&D Canada – Atlantic; January 2012.

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ShipMo3D Version 3.0 User Manual for Computing Ship Motions in the Time and Frequency Domains

4. AUTHORS (Last name, followed by initials – ranks, titles, etc. not to be used.)

McTaggart, K.

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total containing information. Include Annexes, Appendices, etc.)	6b. NO. OF REFS (Total cited in document.)
January 2012	306	27

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

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9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
11ge01	

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ShipMo3D is an object-oriented library with associated user applications for predicting ship motions, with Version 3 introducing modelling of sloshing tanks and U-tube tanks. This report serves as a user manual for ship motion predictions in the time and frequency domains using ShipMo3D Version 3. A companion report serves as a user manual for building ship models that are used as input for ship motion predictions. Time domain simulations can model a freely maneuvering ship in calm water or in waves. SM3DBuildSeaway builds seaway models representing regular or random seaways, including long and short-crested seaways. SM3DFreeMo simulates a freely maneuvering ship in calm water or in a modelled seaway. Several ShipMo3D applications predict ship motions in the frequency domain for a ship with quasi-steady speed and heading. SM3DSeakeepRegular predicts motions in regular waves. The applications SM3DSeakeepRandom, SM3DSeakeepSeaway, and SM3DSeakeepSeawayFromRaos predict motions in random waves. SM3DTimeSeriesFromRaos produces ship motion time series for a ship with quasi-steady speed and heading based on previously predicted motion response amplitude operators.

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frequency domain
maneuvering
ship motions
simulation
time domain
waves

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